W. B. No. 951

UNITED STATES DEPARTMENT OF AGRICULTURE
WEATHER BUREAU

VOLUME 56 NUMBER 3

MONTHLY WEATHER REVIEW

MARCH, 1928

CONTENTS

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON
1928

FRONTISPIECE.—View of watersheds A and B, Wagon Wheel Gap, Rio Grande in foreground. (Heavy circles show location of Dams A and B)

Photos. 90898-9-900, F. S., 1910, A. C. Varela

MONTHLY WEATHER REVIEW

Editor, ALFRED J. HENRY

VOL. 56, No. 3 — W. B. No. 951 — MARCH, 1928 — CLOSED MAY 3, 1928 — ISSUED MAY 28, 1928

SECOND PHASE OF STREAMFLOW EXPERIMENT AT WAGON WHEEL GAP, COLO.

By C. G. BATES, *Silviculturist, Forest Service*, and A. J. HENRY, *Meteorologist, Weather Bureau*

[Reprint from portions of Monthly Weather Review Supplement No. 30 (Forest and Stream-flow Experiment, Wagon Wheel Gap, Colo.)]

HISTORY AND DESCRIPTION OF THE PROJECT

INTRODUCTION

Foresters generally, and nearly all others familiar with the conditions in mountainous regions, believe strongly in the protective value of forests, first, as binding the soil, covering it with humus and litter, and preventing its erosion; and, secondly, as exerting a modifying effect upon the flow of streams. The latter assumption is based primarily upon the obvious fact that the covering of spongy material upon the floor of the forest must prevent the rapid run-off of any normal rainfall, mainly by the absorption of a considerable portion of the water. Of this a certain amount is thus allowed to percolate into the deeper soil where through the medium of underground springs it maintains the even flow of streams. The retardation of snow melting in the western mountains of the United States is another service that forests are believed to perform in the regulation of streamflow and the protection of watersheds, and one which no other form of vegetation could accomplish as well. Thus, in a number of ways, it has been assumed that forests reduce the magnitude of ordinary seasonal floods, tend to maintain stream flow in dry weather, and, perhaps most important of all, prevent erosion of the land which they occupy or adjoin, and thereby reduce the amount of silt carried by streams, and lessen the damage done by flood waters to fertile fields.

The present paper does not attempt to prove or disprove these assumptions, but simply to state them as beliefs which require experimental proof. Present-day needs call for experimental proof of every belief and where great economic values are involved—for quantitative determinations. It is not enough to know *whether* forests influence stream flow; it is necessary to know how much, at what seasons, and under what conditions of climate, soil, and topography, and the variations between different kinds of forest, as well.

At the time of beginning the Wagon Wheel Gap project only one other serious attempt was being made to measure the influence of forests upon stream flow, precisely, and over a long period. The results of this study, comprising 15 years of observation near Emmental, Switzerland, became available in 1919 in an exhaustive report by Dr. Engler.[1] This is perhaps the most authoritative statement on the subject ever published. Yet even here the results are largely qualitative, and the conclusions open to some question, for the simple reason that experimental conditions were not fully attained by first establishing stream flow relationships under similar conditions of cover. The two watersheds on which Engler's work was based, one 97 per cent forested and the other 35 per cent forested—the remainder being in pasture, meadow, and field—were taken in their natural conditions, and comparisons of stream flow have been made only under these conditions.

There is some suggestion that the nonforested character of the one watershed may have been due in part to shallow soil and numerous rock outcrops not favorable to trees, as well as to the treatment it had received. Moreover, up to 1919, no effort was made to measure stream flow during three or four months of the winter, the total amounts of discharge being, therefore, left in doubt in this Swiss study.

The Forest Service began in 1909, with the selection of a site on the Rio Grande National Forest, near Wagon Wheel Gap, Colo., what was to be a very complete study of the effects of forest cover on stream flow and erosion under the conditions of the central Rocky Mountains. The plan, broadly stated, was to use two contiguous watersheds,[2] similar in topography and forest cover; to observe carefully for a term of years meteorological conditions and stream flow under these similar conditions of forest cover; then to denude one of the watersheds of its timber and to continue the measurements as before, until the effects of the forest destruction upon the time and amount of stream flow, the amount of the erosion, and the quantity of silt carried by the streams had been determined. This plan had been executed, and the experiment was terminated by mutual agreement on October 1, 1926.

Because the plan of study contemplated by the Forest Service called for the services of men skilled in meteorological observations as well as the use of considerable instrumental equipment, the cooperation of the Weather Bureau was solicited and, on approval of the Secretary of Agriculture, the two services began on June 1, 1910, the active work of getting material and equipment on the ground. The building of cabins for living and office quarters, the installation of the meteorological instruments, and the construction of two dams occupied the time up to October 22, 1910, when the first meteorological observations were made. Rectangular weirs installed in the beginning did not prove satisfactory and it was not until the following July that satisfactory triangular weirs were installed.

By June 30, 1919, when eight years' continuous stream-flow measurements and nearly nine years' meteorological observations has been obtained, it was concluded that the first stage of the experiment had been adequately developed; it was therefore agreed that one of the watersheds (B) should be denuded at once, except that a strip of timber not to exceed 25 feet in width should be left on each side of the stream for a single season, or until the autumn of 1920. This program was carried out as

[1] Engler, Arnold. Experiments Showing the Effect of Forests on the Height of Streams. Mitteilungen der Schweizerischen Centralanstalt fur das Forstliche Versuchswesen. XII, 1919, Zurich.

[2] Throughout this discussion, and in all of the records the convenient and perhaps more popular word "watershed" is used to denote a drainage basin.

planned, beginning in July, 1919. The larger timber was taken out and the loppings and most of the aspen were piled in windrows and a year later were burned. The other watershed (A) was left untouched during the remainder of the experiment.

Since denuding the one watershed, the records have been continued in the same manner for seven full years, or until October 1, 1926. Thus there are available for comparison of stream flow and contributing factors the records of more than eight years before denuding and of the seven years after denuding, which are comparable in every respect except as to the forest cover affecting the one watershed, and except of course, as successive years vary in their climatic conditions.

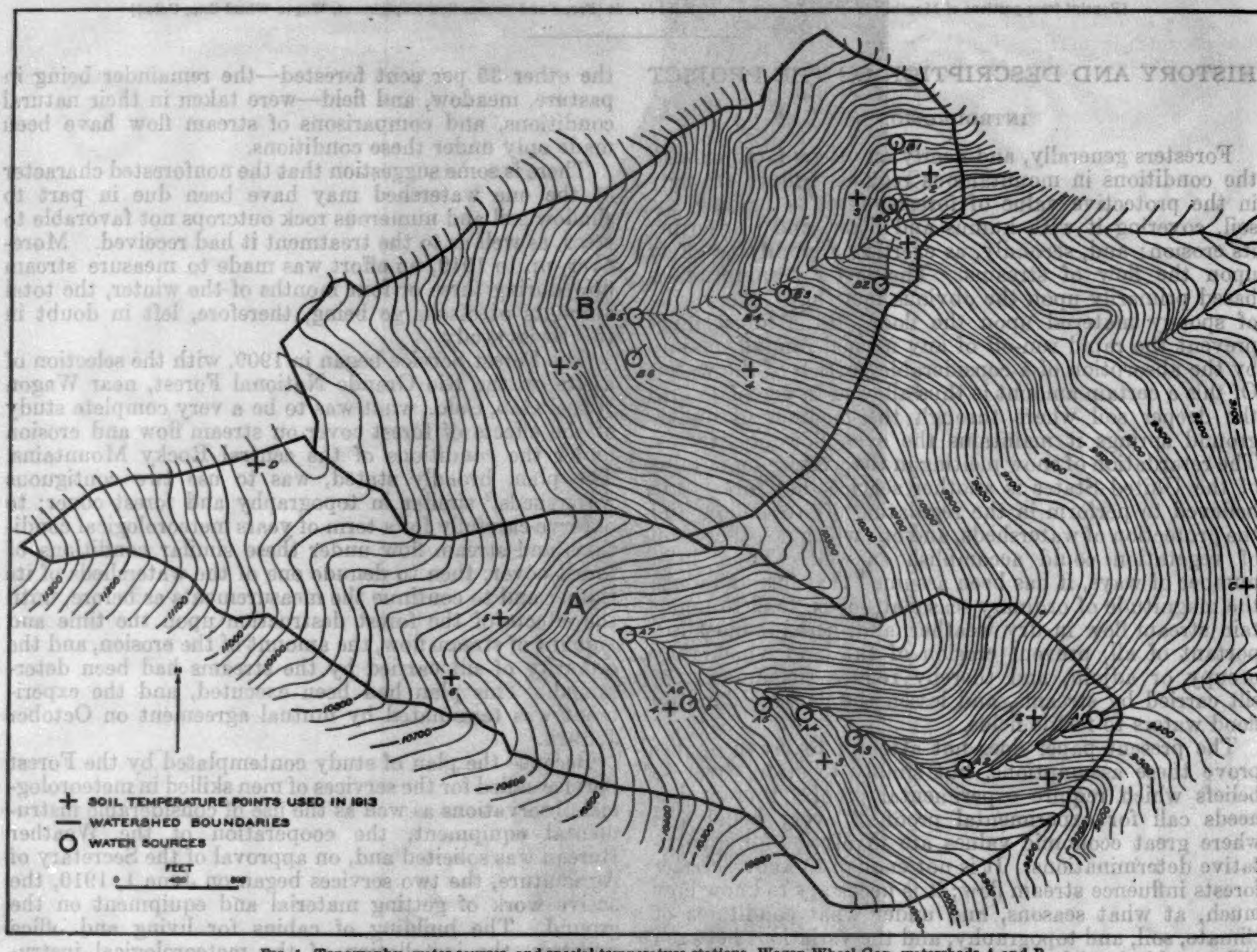

FIG. 1. Topography, water sources, and special temperature stations, Wagon Wheel Gap, watersheds A and B

DESCRIPTION OF THE AREAS

In deciding upon an area for the experiment, the following were the major guiding considerations, their relative importance being indicated by the order in which they are named:

1. That the two watersheds to be studied should be contiguous, or practically so, in order that differences in the amount and time of precipitation reaching them should be as small as possible.

2. That the two watersheds should be on the same geological structure, should have similar altitudinal limits, and, as regards general conformation, general aspect, and steepness of gradients, should be as nearly alike as possible.

3. That the area of each watershed should not be so large as to introduce serious complications in the attempt to relate the stream discharges at the lower extremities to precipitation and other phenomena observed on the areas.

4. That the forest conditions should represent a fair average for the forests of the Rocky Mountain region, rather than the ideal or optimum. To meet this requirement it seemed essential, first, that the forest should be that of a middle elevation, and secondly, that it should not entirely have escaped injury by fires in the past.

TABLE 2.—*Soil composition of bench and slopes*

Class of material	Station D			A-1		A-2	
	1 foot	2 feet	3 feet	1 foot	4 feet	1 foot	4 feet
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Rocks larger than peas	14.2	47.4	34.5	11.4	10.6	30.8	26.7
Coarse gravel	8.0	2.6	1.7	11.2	21.5	17.8	29.0
Fine gravel	6.8	1.4	3.2	9.6	17.6	7.0	10.4
Coarse sand	11.0	7.5	9.9	19.6	18.6	8.8	8.6
Medium sand	6.6	6.0	7.0	10.7	7.9	5.1	3.7
Fine sand	5.4	4.8	5.9	7.4	5.1	4.0	2.7
Very fine sand	11.7	8.4	10.8	8.1	6.3	7.1	5.1
Silt	29.3	16.8	22.2	14.5	7.8	15.6	9.4
Clay	7.0	5.1	4.8	7.5	4.6	3.8	4.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

It should be evident from the rocky character of the soil of the watershed, and still more from the layer of rock fragments covering its surface, that the soil is permeable and receptive to water—a fact of the utmost importance when considering the results of this experiment and their application under other conditions. Whether this ability to absorb water is the primary factor explaining the steady flow of the streams (it is evident from certain calculations that the watersheds can not drain dry in less than 6 or possibly 12 months), or whether the rather remarkable water-holding capacity of the slopes denotes a soil of more retentive character next to the bedrock and in its crevices is perhaps unimportant. It is highly probable, however, that clay in crevices causes a very slow draining out of the water which penetrates most deeply. Such a condition was observed where the dams were constructed.

SUMMARY AND CONCLUSIONS

SUMMARY

CONDITIONS OF EXPERIMENT

1. This experiment deals with streamflow from two mountain watersheds of about 200 acres each, located on the drainage of the Rio Grande in southern Colorado. Their elevations are between 9,000 and 11,000 feet, whereas the areas in Colorado producing living streams extend mainly from 8,000 to the highest peaks, some of which are 14,000 feet in altitude. These watersheds therefore should be average or only slightly below in water-yielding capacity.

2. The geological formation of the locality, a quartz-latite flow of great uniformity over the two watersheds, and the coarse, sandy soil derived therefrom, containing and covered by many small rock fragments, were conducive to a very high degree of absorption of rain and snow water. Hence there appeared very little surface run-off at any stage of the experiment, and the quantities of soil eroded were of extremely small magnitude. Only the coarse granitic soils occurring in portions of Colorado would be likely to show greater absorptive and storage capacities than the soils of these watersheds; the igneous formations, in general, produce somewhat finer soils; the sedimentaries of the high plateaus of southern Colorado and of the foothills of both the eastern and western slopes might be expected to absorb water less readily and to be much more erodable. It is, therefore, evident that a very conservative basis was selected for demonstrating the possible effects of forest removal on streamflow and erosion, particularly the effects of soil disturbance and change.

3. The forest cover of both watersheds, though far lighter than the undisturbed stands at similar elevations in the Rocky Mountain region, was fairly typical of the region as a whole, it having been heavily visited by fires. The original forest was mainly Douglas fir at the lower and Engelman spruce at the higher elevations. These areas were burned over about 35 years ago, watershed B (the one which was denuded in the experiment) having been burned somewhat more extensively than A. The burned areas had come back largely to a scrubby growth of aspen, which, while forming dense thickets and thereby protecting the soil adequately, is obviously less effective than conifers as a shade to retard the melting of snow. Consequently any effect on snow melting from the removal of such a cover would be moderate in comparison with the effect of removing a complete canopy formed by evergreens.

4. Stream flow and the meteorological conditions of both watersheds were recorded continuously from late in 1910 until October 1, 1926, triangular-notch wiers and Friez automatic water-stage recorders being employed to assure the greatest possible precision in the measurements of streamflow.

October 1 was taken as the starting point for the streamflow year, and the data both of stream flow and precipitation have been summarized accordingly from October 1, 1911, for the eight years before denudation of B and the seven years subsequent thereto.

So far as known, this experiment differs from any other experiment of a like nature ever made in that streamflow measurements were maintained throughout the extreme low temperature of winter, −25° F. (−31.7° C.).

5. The denudation of B watershed was started in July, 1919, but was not completed until late in 1920. About one-fifth of the total ground area was burned over and sufficiently heated to prevent the immediate sprouting of the aspen from rootstocks. Elsewhere the vegetation and soil were little affected and a feeble growth of aspen started almost immediately over most of the area. At the end of 1926 this had reached an average height of 4 feet, but conifers were, of course, lacking.

GENERAL CLIMATIC CONDITIONS

6. The outstanding characteristics of climate and streamflow established during the first eight years of the experiment were as follows:

(*a*) A mean annual temperature of about 34° F.

(*b*) A mean annual precipitation of about 21 inches.

(*c*) Precipitation about half snow and half rain. Except on the south slopes there is practically no melting throughout the winter until after March 1. About one-half of the total annual precipitation is released during the melting period, which ordinarily does not end until about June 1. More than 55 per cent of the total annual run-off appears during the flood stage, the average time of which is from March 30 to June 30, under the arbitrary limitations set for it.

(*d*) Owing to differences in conformation and underground conditions of the two watersheds, B is a more effective storage reservoir than A, and consequently its stream neither reaches a peak of flow quite so soon as that of A, nor drains out the excess from the spring flood and storage so soon. The lag during the rise of the flood seems to be further accentuated by the fact that the orientation and other features of B do not permit the early season insolation to be as effective as on A in melting the snow, especially near the stream channel. The importance of this is that the constant lag of B makes difficult the direct comparison of the height of the two streams at any given time. It is apparent from the ratios of run-off to current precipitation that B carries over from one year to the next a greater quantity of ground water than is carried over by A.

(*e*) As much as 42 per cent of the current year's precipitation may appear as run-off when the precipitation is sufficient and snow-melting conditions are favorable and as little as 17 per cent in years of low precipitation and unfavorable climatic conditions.

The losses of water by evaporation remain fairly constant at about 15 inches per annum, although by reason of the hold-over water from one year to another an accurate determination of this point is impracticable.

CLIMATIC COMPARISON OF TWO PERIODS

7. The mean annual temperature of watershed A as deduced from hourly readings for both periods was

identical; considering monthly means, however, there were material differences in several months, thus April, October, and November were colder in the second period than in the first and December was warmer.

The mean annual temperature of B watershed was 0.2° colder than A during the first period and 1.1° warmer during the second; apparently the effect of denudation of B was to increase the annual mean by 1.3°.

8. The mean annual maximum temperature of B in the second period was 2.5° higher than in the first period, and that of A in the second period was 0.4° higher; therefore the net increase in B maximum due to denudation was 2.1°.

9. The mean annual minimum of B watershed after denudation was 0.4° higher than before, whereas that of A watershed was 0.3° lower; the total increase in B minimum attributable to denudation was, therefore, 0.7°.

Summing the increases in both maximum and minimum gives 2.8° and dividing by two gives 1.4° as the total increase in the annual mean temperature, or one-tenth of a degree greater than was obtained by using means deduced from hourly readings.

10. Judging from the record of the A watershed the second period was the less windy of the two. The average velocity for A was 2.2 m. p. h. in the first period and 1.9 m. p. h. in the second period, or a drop of 0.3 m. p. h. The average velocity for the B watershed in the first period was 1.0 m. p. h., and in the second 3.3 m. p. h., an apparent increase due to denudation of 2.3 m. p. h.; but since according to the A record the first period was more windy than the second by 0.3 m. p. h., the corrected velocity for the second period should be 3.6 m. p. h., an increase of about 260 per cent. This result is, however, of strictly local application.

11. Snow melting at all stages was undoubtedly advanced on B as a result of denudation. Judging from the dates of disappearance of accumulated snow from the several snow scales, the average date of snow melting on B watershed has been advanced four days, using A for both periods as a basis of comparison.

12. The mean relative humidity as measured at 9 a. m. at the north slope stations was before denudation slightly greater for B than for A. After denudation most of this difference disappeared. The effect then was to make the atmosphere over B relatively somewhat drier. It is very doubtful whether the difference between B and A at either stage was significant of aything more than slightly different local conditions under which the psychrometers were exposed, of such a nature that observations at another hour might have reversed the relative positions.

EFFECTS OF DENUDATION ON STREAM FLOW

13. In the predenudation years the average annual precipitation on watershed A was 21.03 inches; the average run-off of A was 6.08 inches and that of B was 6.18 inches.

In the postdenudatión period the average precipitation was 21.16 inches, the flow of A 6.20 inches and that of B 7.26 inches. These figures indicate an excess flow from B of about 0.96 inch for the average of seven postdenudation years. The greatest excess was doubtless piled up in the third year and amounted to nearly 2 inches while in the sixth and seventh years it had dwindled to a little more than one-half inch.

VOLUME AND HEIGHT OF FLOODS

14. The greater portion of the excess discharge resulting from denudation occurs in the spring flood and in the earlier part of that flood. Comparisons of the natural flood periods of both streams show that prior to denudation A discharged an average of 3.44 inches and B 3.39 inches in this period. After denudation, A discharged 3.51 inches in the three months of flood, and B 4.25 inches, an apparent increase of 0.79 inch. The distribution of these excesses by years was essentially the same as that of the whole excesses, the third year having an excess of about 1.53 inches.

Treating the floods as covering the period March 1 to July 10 of each year, gives a perhaps more reliable basis for comparison and shows the average excess for B to have been 0.80 inch, or possibly as much as 0.84 inch if factors affecting both streams in the second period be given proper weight. Of the obvious amount, 0.61 inch of 76 per cent is chargeable to the period before May 15, when A stream usually crests, and all has been delivered by June 10.

15. The period of rise from the earliest melting to the crest of the spring flood is perhaps more susceptible to close analysis than any other, because at this time the trends of the two streams are in the same direction; there is little confusion of influences. In the predenudation period B always appeared less susceptible to early melting influences than A and lagged behind from the time the rise of A became rapid and until after the crest of A. In the second period the rise of B was always ahead of A, the beginning having been advanced about 12 days. The volumes discharged up to and including the crest day for A were, in the first period 1.29 inches for A and 1.07 inches for B. In the second period the corresponding quantities were 1.74 and 2.20 inches, the average crest-day being somewhat later in this period. The excess discharge of B during the rise, as a result of denudation, reached a maximum of 1.23 inches in the second year. This occurrence was to be expected as a result of the burning in the fall of the first year. Later the charcoal spots became covered in some degree by vegetation and probably were less effective in hastening melting.

16. The crests of the floods on B were advanced only about three days by the tendency toward earlier melting after denudation, because the crests are usually brought about by, and occur very quickly after, a few exceptionally warm days. The time is usually late enough so that both watersheds are equally affected by the high temperatures. The height of the B crests, formerly averaging only 6 per cent greater than those of A were, however, increased by denudation so that their average excess over those of A was 64 per cent. One crest of B before denudation, that of 1912, exceeded the A crest by 33 per cent. In 1922 crest of B, though not quite so high as 1912, exceeded that of A by 85 per cent. These differences, perhaps more than any others, explain the increased erosion of B watershed after denuding and are characteristic of the extreme effects in the flood stage that are commonly ascribed to forest removal.

17. Except in the second year after denudation when the early flood on B was so much heavier than that on A, there is no indication of appreciable shortages during the declining periods of the floods. The average excess, however, at this time is only 0.12 to 0.19 inch, depending on the use of the "technical" or "arbitrary" flood calculation.

STREAM FLOW DEPENDENT ON STORAGE

The average summer flow of A, July 10 to September 30, inclusive, was 0.90 inch before denudation and 0.90 inch afterwards. That of B was 0.82 inch in the first

period and 0.91 in the second, a gain of 0.09 inch. Analysis of the causes of variations in the summer flow of B stream for different years indicates that size of the spring flood is the most important factor, lateness of the flood has a slight effect, and current precipitation enters in to the extent of approximately 34 per cent of the predenudation flow.

Because of somewhat larger floods on A in the second period, the average summer flow of B should have been probably nearly 0.83 inch. There was thus an excess of about 0.08 inch in the average year, using the flood discharge of A as the criterion.

The distribution is irregular, but the first year after denuding apparently produced the least excess as might have been expected from the incompleteness of the denudation and the lack, at that time, of any accumulated ground water to sustain the flow.

It is well to point out that the slight summer excesses do not necessarily mean a saving of water during the summer period, as is likely to be the first impression. The volume of summer flow is nearly two-thirds dependent on the water placed in storage during the flood stage. Considering the size of the spring floods on B, an excess summer flow of about 0.09 inch on the average might have been expected. Since only this expected flow was delivered, it is more than ever evident that decreased transpiration following denudation was counterbalanced by increase in evaporation from ground surface and from such vegetation as took the place of trees.

19. The fall and winter period, October to February, inclusive, is essentially a period of storage of precipitation and draining out of deeper ground water, since precipitation occurs principally as snow.

There is usually some melting in March, and on B after denudation, nearly always enough to bring the stream up to flood stage about the end of that month. Such melting as occurs on the south exposures throughout the winter must largely be lost by immediate evaporation or may to some extent augment ground water in areas which are mostly too dry to contribute to winter stream flow, because the streams show only occasional slight rises, and in general decline to the middle of February. Possibly as much as 25 per cent of the annual precipitation evaporates during the cold weather, October to February, inclusive, or at least before the snow has all melted.

In the predenudation period the discharge of A averaged 1.40 inches for the period of 5 months and of B 1.59 inches, or, exclusive of the fall flood year (1911–12), 1.28 and 1.47 inches, respectively. The second period seems to have been essentially comparable in winter conditions, although the average December temperatures were appreciably higher in the second period. This, and probably the larger amount of storage water still held over, may account for slightly higher discharge of A, 1.38 inches when compared with the last seven years of the predenudation period; that of B was 1.63 inches. There is thus indicated a gain of 0.06 inch in discharge of B, but analysis shows that the rates earlier in the year might have produced a winter flow from B of about 1.61 inches, so that only 0.02 inch remains as the apparent excess.

20. The slight excess discharge of B during the winter, resulting from denudation, seems not to be accounted for by more effective snow melting, though this undoubtedly occurred to some extent, affecting principally the upper layers of the soil. In the first period, exclusive of 1911–12, B showed an average ratio to A of 1.06 in October, and this climbed steadily to 1.22 in February, indicating that B was being held up more than A by current melting. But it is probable that this steady relative rise reflects only the greater storage capacity of B, in other words, the more complete draining out of A. In the second period, B was absolutely and relatively higher than A in October, the ratio being then 1.15 and this ratio again climbed to 1.22 in February. Furthermore, comparison of the minima reached in February indicates that both streams remained higher in the second period, but B relatively no higher than A. The difference, then, must be due entirely to the higher stage of B throughout the flood and summer stages preceding.

CAUSES OF INCREASED STREAM FLOW

21. The discharge of B, even more markedly than stream A, is kept up after the end of the flood by water probably traceable back to the snowfall of the previous winter. The annual excess flow from B after denudation was nearly 0.96 inch. About 0.68 inch of this excess comes down before the crest of the flood, 0.12 during the decline of the flood, 0.09 in the summer months, and nearly 0.07 inch in the five winter months. If it be said that all of the excess discharge after the flood period is due to decreased transpiration during summer—which plainly is not the case—there is still left the larger part of the total, or about 0.80 inch, which appears as excess during the flood, and most of which can be accounted for only as a saving during the winter accumulation period. Both lack of interception by tree crowns, and a slightly earlier melting in spring, reducing the loss by evaporation, probably contribute to this end. Advancing the melting period in the spring by as much as 10 days may reduce the opportunity for evaporation, which amounts, on the average, to nearly one-half inch for every 10 days of the year, and must be especially great when melting is prolonged and the ground remains saturated well into summer. Another change effected by denudation is to permit the snow to fall more evenly and with less exposed surface—except as it forms drifts—to melt, settle, and crust, and to be less subject to moving about by winter winds. It would seem, however, that the advantages gained in this way would be more than balanced by the greater exposure of the snow to insolation.

The fact that the order of magnitude of the stream-flow excesses during the second period is, except in the first year after the beginning of denudation, the same as that for the amounts of snowfall, makes it appear altogether probable that interception by tree crowns, which was practically eliminated by denudation, is a large factor in evaporation losses during the winter. The amount of such losses would, however, vary with the amount and character of the snow, particularly its wetness, and with the character and density of the tree cover. The savings from 1919 to 1926 were probably abnormally high for the locality of this study, since the snowfall of this period was above the average, but were undoubtedly less than might be expected from the removal of a full coniferous stand.

EROSION AND SILT DEPOSITION GREATLY INCREASED

22. A very important consideration, of course, is that this excess of water flows down the gulch at such time, and in such volume, that it can not be used even in a region in which irrigation is extensively practiced, except by artificial impounding.

Even this appears unattractive when erosion and silting are given proper weight, for engineers are beginning to realize that artificial reservoirs are of short-lived value unless silting can be controlled.

During the predenudation period the average annual silt load carried to the dam by stream A was 691.5 pounds net dry weight, and that carried by B was 568.5 pounds. In the second period A carried an average amount of 477 and B 3,340.1 pounds. The ratio B/A therefore increased from 0.822 to 7.002, or was about eight and one-half times as high after denudation.

23. Most of the larger quantities of silt were obtained in the July cleanings of the basins, covering flood periods after April 15. The ratio of B to A for this quarter before denudation was 0.75 and after denudation 9.12. An increase of about 50 per cent in the average height of B flood crests, together with any direct effects of denudation on the soil, are seen, therefore, to have magnified the silt load of the stream twelve times.

24. Before denudation, one large flood from rain occurred in October, 1911. The silt measurement for 12 months, ending in July, 1912, shows 1,246 pounds of silt from A and 788 from B. In August, 1926, a rain which was far less effective on stream flow, though causing some quick run-off, produced for this quarter only 50 pounds of silt from A and 1,073 from B, the normal ratio for this season being about 1:1.7. The extreme danger of greatly increasing erosion by the disturbances which accompany denudation is thus apparent. And, while all of the silt quantities obtained from these areas are but a tiny fraction of those which may be obtained from highly erodable soils, it is believed the tendencies here shown are indicative of what would obtain under other conditions.

RECAPITULATION

The proportion of the annual precipitation appearing as run-off from year to year in the undisturbed condition of the two watersheds ranged from 17 to 42 per cent. The variations are obviously independent of forest cover and (seemingly more or less fortuitously) depend upon the depth of the snow cover, the time whether in midwinter or in the spring months, at which the bulk of the snow fell; and the occurrence of favorable melting temperatures at a critical time.

The flood run-off of watershed B before denudation was the same as that of A; after denudation of B the spring flood on that watershed increased to a peak discharge in the third year after denudation of about 35 per cent excess and then diminished until the end of the experiment when it was 22 per cent greater than that of A.

Before denudation the general discharge ratio B/A was 1.017, after denudation 1.170. The maximum ratio for a single year was that of the third year after denudation, viz, 1.284, diminishing from that figure to 1.153 at the end of the experiment; the increase in flood run-off did not result in lowered storage or lowered run-off at other seasons.

The load of silt carried before denudation by both streams was very small, after denudation the load on B stream increased say 5 to 15 fold; but even then the erosion was only a fraction of that which would have occurred under different soil conditions, other factors remaining unchanged. There was very little surface flow on B watershed outside of that largely induced by skid trails. Had there been heavy rains and surface run-off the erosion would have been greater.

The climatic conditions of the two periods were substantially the same, with the single exception that the snowfall of the second period was a little greater than that of the first. The changes in the several climatic elements which might be assigned to denudation of the B watershed have already been mentioned.

CONCLUSIONS

In the application of these results to other regions, types of soils, and conditions of climate, there will be many opportunities for differences of opinion. The publication of the basic data of this study—the daily measurements of precipitation and stream flow, Appendix I (Table 66)—will afford students and investigators the fullest opportunity to make independent analyses of the data and to draw their own conclusions. The still more detailed hourly records of stream flow, temperature, precipitation, etc., are on file in the United States Weather Bureau and will be made available under proper restrictions. Nevertheless the writers believe it an obligation to sum up the conditions which produced the results as hereinbefore set forth, and thereby to clarify, so much as may be possible, their application elsewhere by the following brief statements.

It has been pointed out that the areas in question, because of their geological origin and present character of soil, absorb water readily without appreciable surface run-off or erosion and therefore represent excellent reservoirs for the storage of the precipitation that is released in greatest abundance when snow melts in the spring. High heads were produced only when the ground had become saturated with snow water. Climatic and topographic conditions being uniform, it is evident that the height of a flood crest must vary inversely with the ability of a particular watershed to absorb and to hold great quantities of water. The absolute height of the flood crest under a given set of conditions is, therefore, an inverse measure of the value of the watershed for storage.

On the other hand, the low stage of stream flow is also an indicator of watershed conditions. At Wagon Wheel Gap, as elsewhere, the great increase in evaporation in the warm weather of summer, together with the demands of vegetation which flourishes on the abundant moisture left by the winter's snow, causes a rapid drying of the superficial soil layers, which is not relieved until the crest of the heat is passed, and vegetation has aged and waned. In most temperate climates, as in the locality of this study, the peak of demand is probably passed in the latter part of August. There is no evidence in this study that the summer demand for moisture was appreciably affected by the removal of the forest cover. Evidently surface drying proceeded in just about the same way with forest or herbaceous vegetation. Stream flow, then, is on the decline until the lessening of surface demands for moisture permits current precipitation to reach the deeper soil and add to the supply which is flowing slowly toward springs. Stream flow in the midsummer period, in the locality of this study is dependent quite largely on the storage capacity of the watershed. In other localities it may be more, or less, dependent, as the current precipitation is less, or more, adequate to meet the current demands of evaporation. In other words, the low stage of stream flow reached in later summer is in some degree a further measure of the storage capacity of the watershed, and still more clearly a measure of the need for storage capacity.

The ratio of the high stage of a stream to its low stage, as reached within these general limist of time is, therefore, a direct measure of the need for protection of the watershed as a storage reservoir. This ratio, if measured over a number of years, embodies all of the local climatic and soil factors which affect the régime of streams. The higher the ratio, the more apparent it is that everything possible should be done to lower flood crests by retarding the melting of snow in the spring or increasing the

capacity of the soil to absorb quick accessions of water at any time. The higher the ratio, the more evident it is that either in spring freshets or those following heavy rains at any season, water is running off, often superficially, in a hasty, useless, and destructive manner.

The ability of any vegetative cover to assist absorption, thereby reducing surface run-off and erosion under nearly all conditions and the ability of a forest cover in particular to retard snow melting, can not be seriously questioned. On the other hand, a locality whose soil or climatic conditions are not conducive to extremes of run-off obviously does not have the need of a protecting influence in the same degree as a region or watershed whose streams are not permanent and whose freshets may yet be strong and destructive. In the absence of direct measurements of stream flow, the extent to which erosion of a watershed has occurred may be used as a basis for estimating the liability of great extremes of run-off.

On the watershed denuded in the present study the original ratio of high to low stages was about 12 to 1 and this was increased only to 17 to 1 by denudation. The high stages were made much higher and the low stages were made slightly higher. In other words, though the snow water was made available earlier and in more concentrated volume, the watershed was still capable of absorbing it after denudation and of retaining for discharge throughout the year a greater volume than before, although the amount retained was not increased in proportion to the flood volumes. It is obvious that the storage water could not have been increased even to this extent if these watersheds showed any markedly increased tendency to yield surface run-off after denudation. Any flood excess of water that does not go into the storage reservoir, can have no effect on the low water flow from that reservoir. A further factor tending to reduce the low water flow will be the advance in the time when the maximum storage is attained.

It is therefore proposed that the ratio of high to low stages indicates the liability of failure of the watershed to exercise its full storage function and hence the need for protective influences which will cause that function to be exercised to the fullest possible extent, with the *probability* that so far as spring storage is increased summer flow will be increased, and will not be appreciably decreased by the growing-season drain of the forest cover.

From the evidence of this study it is estimated that in a locality where the normal ratio of high to low stages is more than 25 to 1 with a moderate protective cover, the probabilities are strong that the low stages would be made still lower by removing that protection. The very great possible latitude in this ratio is illustrated by the stream flow records published by the water resources branch of the United States Geological Survey, which show for streams much larger than those here dealt with (and whose extremes are, therefore, subject to more compensating factors) ratios commonly as high as 50 to 1 and occasionally as high as 150 to 1 or even higher. These ratios indicate the infinite possibilities for variation in the climatic and soil factors affecting absorption and retention by watersheds and the need for careful inductive reasoning in the attempt to relate even qualitatively the results derived from one set of conditions to those which might be given by another set of conditions.

APPENDIX 1

TABLE 66.—*Daily run-off in hundred-thousandths of an inch over watershed and precipitation in hundredths of an inch* [1]

1911-12

Date	October Precipitation A	October Precipitation B	October Run-off A	October Run-off B	November Precipitation A	November Precipitation B	November Run-off A	November Run-off B	December Precipitation A	December Precipitation B	December Run-off A	December Run-off B	January Precipitation A	January Precipitation B	January Run-off A	January Run-off B	February Precipitation A	February Precipitation B	February Run-off A	February Run-off B	March Precipitation A	March Precipitation B	March Run-off A	March Run-off B
1	26	28	1470	1239	21	21	1786	1698			1298	1245			1030	1098			964	1057	27	30	888	1033
2	2	4	1157	1156	T.	T.	1781	1684			1290	1238			1046	1091			969	1062	14	14	898	1040
3		T	1083	1108			1725	1649			1273	1235			1038	1080			960	1069	4	4	915	1049
4	76	72	1153	1147			1706	1623			1264	1228			1036	1093			952	1069	24	24	923	1047
5	254	274	6340	4725	5	6	1711	1601			1271	1235			1048	1093			952	1069		T.	1022	1061
6	T.	T.	6161	5025			1669	1587			1262	1224			1038	1097			948	1069	20	19	1087	1075
7			6448	5193			1643	1560	4	4	1259	1222	14	13	1042	1105			944	1069	10	12	1006	1075
8			5821	6285	14	14	1654	1566			1233	1210			1048	1105			962	1063	4	4	967	1074
9			4924	6958	16	14	1626	1542			1234	1200	T.	T.	1038	1105			927	1073	1	1	947	1060
10			4252	6502	12	12	1596	1530			1239	1200			1030	1103	T.	T.	931	1072	44	44	931	1080
11			3786	5772	25	30	1584	1519			1221	1187	T.	T.	1027	1093			931	1069			912	1074
12			3454	5012			1526	1477			1219	1174			1016	1093	1	1	931	1069	5	5	905	1062
13			3197	4442	T.		1550	1479	2	2	1216	1161			1009	1098			916	1069	48	50	902	1074
14			3022	3973			1544	1460			1191	1143			1010	1107			915	1067			911	1055
15			2856	3584			1523	1429			1177	1140			1005	1105	T.	T.	920	1057			909	1058
16			2729	3247	1	1	1519	1420			1177	1140	11	10	1016	1105	4	2	914	1055	5	4	911	1054
17			2628	3022			1482	1404	9	8	1166	1140	11	11	1009	1103			917	1045			926	1051
18			2519	2815			1470	1388	88	85	1177	1144			995	1093	3	4	932	1055			1070	1063
19			2441	2645			1465	1366	4	4	1166	1154			995	1095	T.		924	1055	34	34	1035	1079
20	T.	T.	2358	2499			1443	1354			1150	1164			981	1079			909	1045	18	18	981	1111
21	2	2	2286	2360			1437	1354			1130	1164			964	1072			899	1043	2	3	983	1107
22			2210	2273	8	10	1420	1354			1123	1163			966	1062			899	1040	18	18	1057	1145
23			2142	2174			1389	1330			1123	1152			991	1067	2	2	899	1045	2	2	1053	1129
24			2105	2092			1370	1307	9	8	1123	1150			986	1057	20	14	899	1045			1068	1114
25			2045	2022			1360	1295	16	14	1123	1140			981	1057	17	11	901	1043			1099	1116
26	24	24	1990	1960	T.	T.	1358	1301	T.	1	1112	1124			961	1059			891	1050	2	2	1120	1141
27	34	38	1971	1908	10	9	1346	1294			1104	1105	T.	T.	984	1075			877	1046	2	2	1085	1133
28			1948	1873			1324	1271			1111	1105			984	1081			877	1048			1042	1144
29	23	24	1925	1853			1306	1257	22	21	1102	1105			973	1075			870	1036			1071	1158
30			1885	1804			1303	1250			1106	1105			966	1069					7	6	1086	1162
31			1822	1768							1078	1103			974	1060					14	12	1048	1151

1912-13

Date	October Precipitation A	October Precipitation B	October Run-off A	October Run-off B	November Precipitation A	November Precipitation B	November Run-off A	November Run-off B	December Precipitation A	December Precipitation B	December Run-off A	December Run-off B	January Precipitation A	January Precipitation B	January Run-off A	January Run-off B	February Precipitation A	February Precipitation B	February Run-off A	February Run-off B	March Precipitation A	March Precipitation B	March Run-off A	March Run-off B
1	8	7	1093	1168			1041	1216			932	1118	6	6	929	1047	1	1	874	1059			781	1024
2	10	10	1100	1191			1030	1208	T.	T.	948	1121			920	1048	11	10	866	1057			788	1016
3	T.	T.	1104	1205	1	1	1059	1216			941	1122			920	1068			855	1061			799	1026
4	13	13	1123	1202			1043	1199	13	10	949	1122	8	6	923	1074			837	1049			819	1017
5	35	37	1178	1268	T.	T.	1037	1178	31	30	957	1116	54	44	929	1072			798	1039			842	1013
6	20	20	1173	1290			1022	1188			952	1109	2	2	920	1072			802	1039	4	4	829	1015
7	2	2	1210	1268			1024	1196			941	1109			896	1071			813	1039	4	4	825	1019
8	4	4	1150	1258			1022	1190			941	1108			892	1058	T.	T.	824	1033	T.	T.	834	1019
9	24	25	1100	1237			1029	1188	2	3	949	1109	1	1	903	1061	T.	T.	803	1033			851	1020
10	24	26	1133	1254			1027	1189			936	1105	26	28	909	1073	1	T.	806	1025			855	1033
11			1125	1262	38	36	1027	1212			921	1105			901	1067	T.	1	813	1026	10	10	872	1021
12			1095	1252			1023	1205			931	1094			888	1059			802	1021	23	26	866	1026
13			1049	1240			1012	1189			920	1105			888	1047			794	1025	4	4	854	1020
14			1040	1217			1002	1177			920	1094			888	1050			779	1021			841	1008
15			1055	1206			1000	1176	4	4	925	1099			888	1046			781	1023			824	1002
16			1055	1211			990	1164	9	8	937	1105	12	12	898	1051			781	1024			824	989
17			1057	1200			988	1164	5	4	909	1109	T.	T.	899	1048			787	1027			835	993
18			1052	1200			965	1158			898	1105			890	1012	11	11	797	1050	5	6	852	1000
19	4	6	1063	1210			963	1154			899	1104			896	1071	15	12	802	1038	3	3	870	1018
20	4	4	1059	1212			975	1157			898	1001			897	1078	34	34	804	1031	4	4	875	1012
21	4	5	1080	1218			984	1155	4	4	894	1081			888	1069	1	2	780	1024	1	1	850	1021
22			1042	1189			1003	1142	1	1	897	1080			899	1072	10	10	812	1026	6	6	899	1049
23			1050	1188			1013	1140			[2] 885	1067			888	1070			810	1026	50	52	911	1041
24			1046	1177			1006	1140			901	1066			888	1075	2	2	803	1021	20	27	888	1020
25			1034	1165			986	1134	2	4	909	1073			888	1077	10	10	804	1021	6	8	869	1011
26			1042	1173			968	1140			906	1061			888	1062	6	5	824	1028			865	1004
27	54	54	1198	1274			953	1130			905	1047			888	1044	8	10	812	1025			869	1014
28	3	3	1223	1305			941	1120			911	1049			886	1051			800	1025			936	1043
29			1066	1271			941	1109			935	1058			881	1052							1131	1111
30	43	43	1064	1246	5	7	941	1116	1	1	932	1079			878	1064							1474	1264
31	1	1	1048	1222					T.	T.	922	1053	1	T.	871	1067							1948	1409

1913-14

Date	October Precipitation A	October Precipitation B	October Run-off A	October Run-off B	November Precipitation A	November Precipitation B	November Run-off A	November Run-off B	December Precipitation A	December Precipitation B	December Run-off A	December Run-off B	January Precipitation A	January Precipitation B	January Run-off A	January Run-off B	February Precipitation A	February Precipitation B	February Run-off A	February Run-off B	March Precipitation A	March Precipitation B	March Run-off A	March Run-off B
1	18	18	1054	1057	T.	T.	866	962	60	56	823	938	14	12	781	915	T.	T.	761	898			822	891
2	13	14	989	1042	16	15	861	966	3	4	817	934			788	915			770	894	39	36	838	907
3	24	27	1119	1095	62	58	875	984	60	58	822	938	10	10	792	920			770	884			821	904
4	4	6	1014	1075			870	981	61	58	837	950			782	915			774	893			800	902
5	8	10	980	1051			866	980	T.	T.	848	965			781	909	6	6	781	898	T.	T.	809	904
6			970	1036			869	971			826	941			781	906	3	2	778	893			802	901
7			949	1020			877	980			814	938			781	907			768	890			809	905
8			948	995			863	973			823	938			782	918			759	878			820	911
9	20	19	937	998			856	967			819	936	2	2	789	906			759	873			841	916
10			943	996			844	968			812	931			779	901			764	873	2	1	840	929
11			936	987			839	962			796	925			770	899			777	877	1	1	835	935
12			940	989	10	10	858	964			800	920			770	903	5	4	778	883			838	930
13			950	986	33	35	866	980			794	919			770	900			759	875			841	931
14			933	986	T.	T.	866	983			802	921			772	903			753	872			856	941
15			915	986			845	983			792	922			781	903			755	867			875	944
16	6	7	934	984			832	970	3	4	812	932	18	18	781	903			767	867			904	966
17			934	982			848	963	2	1	813	938	6	6	781	903			779	873			943	1000
18			901	974			850	968	40	38	814	938			781	909	T.	T.	774	885			941	1019
19	T.	T.	902	974	8	7	860	980			818	934	6	5	781	910	2	2	772	874			927	1033
20			899	974	32	28	878	989			802	916			781	903			781	887			903	1010

[1] For monthly totals of precipitation see Tables 36 and 37, and for monthly totals of run-off see Tables 51 and 52.
[2] Break in Dam A discovered and certain record begun.

TABLE 66.—*Daily run-off in hundred-thousandths of an inch over watershed and precipitation in hundredths of an inch* [1]

Date	April				May				June				July				August				September			
	Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1912																								
1			1024	1140			4512	3280			6272	6379	3	4	2202	1906	6	6	1576	1438			1128	1123
2			1067	1162			5132	3746			5854	5839	T.	T.	2148	1845			1529	1372			1095	1107
3			1256	1229	5	6	4490	4041			5447	5411	6	8	2096	1800			1484	1336			1086	1077
4	T.	T.	1291	1307		T.	3680	4067			5084	4990	10	10	2131	1800	10	8	1480	1319	8	8	1085	1083
5	10	8	1303	1322			3450	3965			4801	4022			2038	1763	2	2	1476	1311			1042	1061
6			1347	1373			3876	3355	T.	T.	4542	4313			1977	1712	1	1	1447	1298			1042	1042
7			1499	1449			5386	3069	26	27	4435	4111			1925	1659			1411	1267			1035	1088
8			1463	1467		T.	8196	4442	1	1	4168	3865			1854	1618			1367	1254	2	3	1042	1045
9			1677	1559	14	11	9227	5067	6	6	3977	3650			1807	1581	13	10	1342	1232	2	4	1067	1062
10	3	2	1851	1509			7300	5697			3770	3474	1	1	1770	1542			1313	1209	1	1	1080	1087
11	22	23	1679	1663			7561	6070	2	1	3612	3313	2	1	1771	1515	1	T.	1295	1192	25	20	1134	1116
12	30	32	1755	1701			10510	6384	3	3	3483	3184	19	22	1748	1530	2	2	1320	1199	T.		1079	1119
13			1629	1646			10963	6929	T.	T.	3353	3068	4	4	1697	1519	24	23	1384	1237	T.		1059	1104
14			1530	1602	14	14	9750	7218		T.	3233	2978	16	18	1702	1521	50	48	1634	1360	2	2	1067	1110
15	3	2	1428	1562			8910	7115			3122	2858	36	38	1786	1584	22	26	1496	1372			1067	1112
16	1	1	1439	1620			9365	7372			3006	2737	20	18	1754	1536	T.	T.	1420	1338			1054	1101
17	6	6	1399	1681			13349	8282	24	27	3038	2676	7	4	1680	1509	9	10	1420	1341			1060	1118
18	8	8	1370	1677			16534	10695	1	1	2901	2584	12	16	1659	1506	T.		1362	1307			1071	1124
19	34	32	1360	1684			17458	14571			2790	2474	16	15	1672	1485	6	2	1350	1276			1072	1135
20	18	18	1355	1704			17566	17344			2684	2376			1581	1435	2	2	1317	1255			1057	1141
21	1	1	1307	1686			17099	21685	T.	T.	2614	2291	30	32	1602	1429			1272	1224			1063	1144
22			1272	1669			15956	23351	54	62	2742	2351	20	13	1647	1450			1224	1193			1091	1164
23			1359	1682			14077	21422	3	4	2628	2274	20	18	1653	1457			1196	1154			1094	1164
24			1645	1826			12051	18060	15	12	2503	2203	32	41	1780	1536			1173	1134	3	4	1096	1173
25	2	2	1564	1950			10538	15261	1	1	2426	2112	T.	2	1658	1501			1151	1116	T.		1082	1164
26			1612	2012			9510	13261	29	22	2413	2078	76	90	2045	1726		T.	1108	1099			1091	1164
27	16	19	1609	2060			8806	11680	16	9	2444	2036	16	18	1899	1734		T.	1143	1105			1096	1164
28			1600	2168			8216	10133	4	4	2314	1967	14	15	1744	1664	2	2	1145	1104			1094	1153
29			1994	2381			7058	8900	34	33	2462	2008	48	35	2036	1659	4	4	1135	1110	T.	1	1091	1154
30			2857	2783	1	2	7236	7902	1	1	2323	1957	T.	5	1888	1615	23	24	1203	1155			1106	1164
31							6724	7045							1674	1527	1	1	1161	1142				
1913																								
1	T.	T.	1935	1416			3605	3375	T.	T.	1916	2183			1448	1649	T.	T.	902	923	22	30	801	863
2	16	18	1513	1371			3480	3601			1894	2142			1384	1595			836	909	4	8	836	888
3	T.	T.	1322	1307	2	2	3328	3763			1870	2109			1335	1535			858	882	15	23	834	904
4			1554	1262			3226	3813	T.	1	1851	2065			1291	1470			818	871	20	14	851	900
5			2037	1330			3144	3727	T.	T.	1826	2023	T.	T.	1261	1388	4	4	821	876	T.	T.	841	887
6	T.	1	[3] 2455	1406	T.		3022	3599	T.	T.	1805	1979	2	2	1267	1365	1	1	824	834	T.	T.	799	862
7	11	11	2402	1402	T.	T.	2954	3533	53	53	1949	2037	6	12	1249	1362	T.	T.	807	831	12	14	800	862
8	20	23	1997	1368	8	9	2931	3521	24	24	1905	2057	2	4	1223	1330			796	820	30	30	888	908
9	T.	T.	1651	1337			2899	3603	38	45	1933	2092	1	1	1202	1294	4	4	808	830	2	4	876	904
10			1420	1293			2848	3823	62	69	2329	2385	T.	1	1166	1265	16	22	826	849	1	1	837	911
11			1374	1278			2801	3987	10	10	2401	2473			1100	1215	26	20	896	869	8	14	850	919
12			1863	1319			2775	4026	42	45	2421	2649			1070	1164	70	66	1132	1012	4	6	849	914
13			2921	1440	2	2	2744	4015			2328	2736	2	2	1034	1124	13	12	969	974			832	910
14			3906	1602	T.	T.	2709	3974			2209	2747	4	2	1025	1083	T.	T.	898	957	T.		828	890
15			3622	1657			2635	3892			2129	2745	12	12	1030	1079			837	910	4	4	824	892
16			4056	1816	T.	T.	2580	3799	T.	1	2102	2718	T.	1	1042	1077			825	875			817	886
17	1	1	3376	1891	1	T.	2514	3635	11	9	2160	2688	9	14	1033	1105	5	6	836	866			813	893
18	20	22	2992	2015			2437	3484	21	19	2197	2664	37	44	1112	1148	16	18	891	894			823	887
19			3443	2147	5	6	2389	3353	1	1	2104	2636	46	48	1203	1203	7	6	881	895			814	889
20			3530	2344			2325	3188			2002	2561	62	65	1382	1301	8	9	885	911			809	882
21	T.	T.	3452	2503			2256	3025	T.	T.	1948	2471	24	21	1289	1286	T.	T.	873	910			824	891
22	10	10	3214	2455			2193	2867	T.	T.	1874	2417	6	6	1265	1262	14	16	839	900	58	60	975	978
23		T.	2902	2262	T.		2138	2758	16	16	1856	2369	13	12	1190	1225	T.	T.	814	871	51	55	949	973
24			2665	2125	T.	T.	2099	2678			1806	2300			1117	1161	36	39	911	930		T.	934	993
25			2528	2061	T.	T.	2056	2578			1727	2178	T.	T.	1059	1098	8	8	885	909	4	4	928	991
26			2797	2230	T.	T.	2023	2505			1653	2080			1027	1063			811	896			939	1021
27			2836	2543	30	34	2144	2521	8	9	1603	1972	T.	T.	996	1024	1	1	791	855	2	4	972	1049
28			3016	2926	1	1	2071	2467	16	18	1680	1958			975	1007	1	1	794	842			1009	1045
29			3207	3056			2003	2375			1576	1837	T.	1	955	989	2	2	792	832	T.	T.	992	1017
30			3509	3235			1970	2316			1496	1724	3	3	949	969	4	6	769	835	6	8	943	993
31					T.		1942	2247					1	1	925	954	1	1	760	836				
1914																								
1			910	1060	50	60	2702	3056	18	10	4267	4447	18	18	1722	1346	3	2	1445	1103			1035	890
2			944	1085	1	1	2728	2101	9	10	4040	4073	10	8	1673	1333	T.	T.	1370	1053			989	879
3			974	1149	T.	1	2758	2181			3835	3789	6	8	1679	1333	1	2	1339	1031			973	850
4	T.	T.	1040	1239	8	6	2762	2255	2	4	3637	3541	34	32	1790	1401	4	4	1319	1011			956	841
5	T.	T.	1163	1346	4	4	3171	2417	T.	T.	3468	3319			1648	1355	T.	T.	1244	979	3	4	964	847
6	T.	T.	1345	1406	T.	T.	3779	2645	2	2	3325	3164	10	10	1577	1296			1211	954	T.	T.	961	840
7	T.	1	1449	1407			4596	3044	4	4	3202	3006	1	1	1582	1260	15	18	1251	964			933	831
8	7	4	1432	1357			5577	3601	T.	T.	3053	2858	T.	T.	1545	1234	16	14	1296	976			919	833
9			1410	1301			6557	4079			2898	2700	5	4	1486	1182			1231	952	10	10	956	872
10	16	16	1348	1285			7269	4040			2795	2577	T.	T.	1471	1166	T.	T.	1200	951	T.	T.	964	859
11	16	17	1207	1296	T.	T.	7270	5512			2708	2462	T.	1	1432	1130			1170	926	4	4	975	875
12			1303	1303	T.	T.	6960	6413	T.	1	2612	2351	26	26	1468	1145			1118	898	32	29	1053	915
13			1389	1373			6583	6712			2504	2244	30	20	1563	1168	T.	T.	1092	873	44	42	1283	1053
14			1654	1509	68	59	6623	6807	T.	T.	2458	2131	14	17	1491	1164	T.	T.	1073	859	15	15	1129	996
15	T.	T.	1027	1565	T.	T.	6944	7092	70	74	2668	2221	22	18	1515	1184	3	2	1052	848			1063	975
16	2	2	2112	1564	T.	T.	6521	8586	7	7	2464	2147	67	68	1459	1156	29	30	1109	868			1042	951
17	4	4	1952	1551	2	1	6445	8533			2331	2041	102	96	2011	1353	4	3	1101	870			1023	942
18			1790	1542	8	6	6241	8330		T.	2232	1939	28	24	1962	1343	36	28	1164	899			1011	936
19			1896	1614	T.	T.	5857	8085	T.	T.	2174	1851	28	25	1906	1381	T.	T.	1101	887			1019	945
20	T.	T.	2138	1697	4	3	5487	7777			2115	1783	T.	T.	1678	1279	26	24	1146	922	27	26	1048	965

[3] Break in Dam A caused correction to be applied to all readings for ensuing 3 months.

TABLE 66.—*Daily run-off in hundred-thousandths of an inch over watershed and precipitation in hundredths of an inch*—Continued

Date	October				November				December				January				February				March			
	Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1913-14																								
21			893	965	T.	T.	866	986			802	928			765	903	39	38	799	902			877	987
22			889	962			835	971			793	919	8	8	770	903	12	12	796	903			854	983
23			877	962			810	943	4	4	796	919			770	903			774	895	T.	T.	866	984
24			875	961	20	20	829	948			785	917	7	6	771	896			761	878	23	22	883	1001
25			873	951			846	938	4	4	782	909	8	8	781	891	T.	T.	761	868			894	991
26			851	944			836	938	5	4	792	921	37	36	781	904			768	867			919	1022
27	T.	T.	851	952			825	938			784	915	94	88	781	913			761	872			961	1084
28			866	950	2	2	822	938			781	920	12	15	783	903			800	883	T.	T.	954	1108
29			848	950			813	939			781	917			781	901					8	8	965	1105
30	T.	T.	856	950	6	6	813	934	T.	1	781	912			775	895					3	4	942	1077
31	T.	T.	861	950					T.	T.	781	909			776	892							897	1048
1914-15																								
1	3	4	993	963			886	987	4	3	658	940			872	974			834	922	5	4	761	912
2	15	16	1009	977			877	991	2	2	711	945			850	972	14	14	834	913			759	906
3	75	76	1125	1066			867	986			754	942			836	970	44	43	847	926	2	1	750	903
4	1	1	1235	1099			854	986			836	929			848	986	T.	T.	834	927	T.	T.	749	901
5			1030	1049			846	984			796	915	6	6	866	986			811	938			748	881
6			1024	1014			836	984	10	8	800	918			864	983			788	934			727	893
7	T.	T.	1019	998			838	984	4	4	824	938			866	969			781	938			729	883
8			1006	989			836	974	3	2	804	937			861	977			781	934			738	891
9	9	9	1012	999			831	970	1	T.	767	928	2	3	866	978			781	939	4	4	738	891
10			998	986			829	973			760	927			866	968			781	937	T.	T.	738	896
11			992	986			821	975	2	1	796	918			861	958	78	77	781	938	12	10	738	902
12			975	986			804	971			747	912			852	974	34	32	781	944			732	884
13	T.		972	979			818	978			681	803			837	969			780	954			729	879
14			963	972			827	983			532	850	6	4	819	967			763	957	T.	T.	735	877
15			963	972			816	986			453	832	15	14	817	974			763	935	T.	T.	747	893
16			963	984			806	984			442	830			813	969	T.	T.	770	943			756	892
17			962	986			808	980	T.	T.	468	816	T.	T.	802	955	1	T.	761	946			762	894
18			939	986			795	970	16	15	569	849			802	976			765	943	10	12	772	905
19			936	986			759	961	52	47	627	873			802	959	10	10	764	938	T.	T.	767	903
20			931	986			787	955	14	14	667	902			805	958	14	14	770	938			764	891
21	49	50	1018	1044			740	958			664	904			823	963	12	12	769	938			749	880
22	3	3	1081	1078			736	952			702	938			828	958			758	938			776	901
23	60	58	1081	1086			744	950	4	4	774	961			804	957			755	926			804	935
24	6	6	1015	1100			727	946	12	12	702	982			825	955			744	915			812	938
25			1023	1098			742	946			728	986	T.	T.	828	945	10	12	749	913	T.		838	967
26			977	1070			745	947			880	986			832	933	24	26	759	903			855	1002
27			954	1037			749	947			903	986			830	912			776	905			866	1014
28			915	1021			737	948	2	2	909	1002			809	900			767	903			841	995
29			905	1011	2	2	698	950			888	985	50	48	833	900					2	4	830	991
30			900	1004	T.	T.	685	950			876	977	14	13	834	933							830	988
31			898	991							868	981	T.	T.	834	925							822	987
1915-16																								
1			906	903			834	893			760	870			722	869			686	843	20	20	706	884
2			902	903			834	889			735	867			715	867	T.	T.	685	843			689	873
3			906	903			843	891			729	867			706	867	2	2	679	849			677	857
4	6	6	900	903			837	891	3	3	756	872			706	872	3	4	685	855			704	872
5			904	903			834	891	15	15	759	892			713	867	2	2	685	852			710	880
6			902	903	36	36	852	912			759	879	9	8	717	873			677	843	50	46	706	889
7			891	899	6	6	875	932			759	879			710	867			678	851			708	891
8			878	879			845	926			742	877			706	867			685	854			825	946
9			880	880	28	29	849	923			739	867	3	3	717	868			677	846			1021	1075
10			897	894	101	106	866	938			744	867	8	8	727	884			664	849			1161	1146
11	T.	T.	888	903			845	933			741	867	22	21	727	879			694	859			1253	1149
12	T.	T.	878	903			819	906			727	867			719	870			702	859			1367	1154
13			878	903	T.	T.	831	913			713	867			710	867			702	855			1487	1208
14			888	900			824	903	4	4	728	867	8	9	706	867			703	845	3	4	1428	1229
15	18	18	901	906			821	903	46	41	754	876			706	867			714	849			1248	1174
16	12	11	944	925	T.	T.	813	903	T.	T.	745	867			706	867			739	850			1275	1180
17			944	940			813	900	T.	T.	727	867	50	51	706	863			761	852			1364	1215
18			908	927			806	897			726	865	63	65	706	867			773	861			1418	1228
19			894	922			802	893			700	855	30	30	706	876			777	857			1461	1305
20			877	911			804	901			711	846	2	5	706	867			774	852			1565	1418
21			874	910			817	902			698	855			702	860	2	3	754	855	5	6	1652	1504
22			874	903			808	904			706	855			687	850	6	6	727	860	9	8	1580	1471
23			872	903			796	903	2	2	704	861			692	855			727	857	34	32	1502	1513
24			866	903	19	17	792	903			706	865	T.	T.	701	857			720	857	T.	T.	1415	1510
25			866	903			791	903	2	2	699	849	8	8	706	867			709	861			1298	1434
26			854	902			777	883	16	16	702	867	12	12	706	867	10	10	718	862			1221	1376
27			844	900	6	6	787	895			709	866	70	60	706	867	14	16	721	869	T.	T.	1191	1359
28			838	903			763	881	T.	T.	710	855	47	46	706	874	6	7	710	877	T.	T.	1218	1408
29			839	903			763	880	14	14	717	855	6	6	706	867	2	2	706	869	T.	T.	1221	1432
30			834	899	T.	T.	770	890	56	55	717	856	8	8	706	870					46	38	1215	1395
31			834	903					117	116	721	869			692	854							1190	1367

TABLE 66.—*Daily run-off in hundred-thousandths of an inch over watershed and precipitation in hundredths of an inch*—Continued

Date	April				May				June				July				August				September			
	Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1914																								
21	T.	T.	2297	1693	2	1	5213	7306			2040	1712	12	10	1592	1216	22	22	1180	951	2	2	1099	998
22	28	25	2355	1715	19	20	5163	6889			1981	1641	T.	T.	1507	1159	26	23	1252	988			1024	970
23	6	6	2198	1785	34	39	5336	6639			1908	1581	2	1	1444	1114	T.	T.	1145	961			1005	959
24	T.	T.	2138	1844	18	20	5705	6608			1859	1527	3	3	1455	1101	T.	1	1089	931			1006	986
25			2492	1919			5528	6702			1800	1483	53	62	1576	1214	2	2	1070	909			1011	984
26	T.	T.	2720	1908			5626	6722			1718	1423	12	11	1518	1194	12	14	1103	918	T.		996	947
27	7	6	2725	1897	4	4	5478	6623			1691	1386	10	8	1445	1162	1	T.	1074	899			993	948
28	10	10	2616	1901	T.	T.	5205	6297			1644	1350	23	24	1477	1164	4	2	1047	886			976	957
29			2636	1996			4865	5725	T.	T.	1619	1303	6	10	1470	1172	12	14	1079	913	T.	T.	985	908
30	T.	T.	2714	2064			4584	5236	46	47	1814	1373	34	34	1457	1187	5	4	1083	911	3	4	996	965
31							4367	4786					28	10	1482	1156	4	2	1064	915				
1915																								
1			880	1004	29	28	3687	2585	10	9	4001	4605			1693	1449	T.	T.	1051	920			730	699
2			915	1037	1	T.	3354	2484			3914	4353	T.		1646	1403	T.	T.	1068	894	2	2	732	701
3			915	1059			2995	2446	5	3	3756	4125			1618	1361			1034	873	24	26	822	754
4			983	1101	1	1	2692	2415	20	22	3645	3916	4	4	1600	1334			990	855	22	24	870	787
5	15	14	915	1120	13	14	2486	2420	15	16	3671	3780	2	2	1573	1309		T.	996	837	T.	T.	834	772
6	42	40	886	1117	28	28	2464	2369	T.	1	3495	3630			1479	1262	64	58	1147	908			805	769
7	T.	T.	953	1146			2707	2372			3369	3485			1424	1226	3	3	1187	926			788	757
8	T.	T.	933	1149	T.	T.	2752	2379	T.	T.	3308	3346			1391	1196		T.	1075	907			758	739
9	9	9	891	1159	T.		2935	2437			3246	3219			1328	1152			995	867			735	720
10			964	1162			3481	2747			3176	3127			1297	1122			971	846			704	695
11			1033	1170			4640	3329			3085	3019			1260	1086	10	12	990	853			686	689
12			1079	1169			6052	4316			3014	2912	T.	T.	1259	1065			988	830	T.	T.	679	679
13	31	33	995	1192	T.	T.	7780	6365			2925	2806	25	22	1325	1092	T.	1	950	809	54	74	852	826
14	2	2	1190	1327	T.	T.	6845	6062			2852	2697			1301	1051	4	4	974	820	5	5	806	774
15	22	21	1096	1268			7163	6841			2780	2608			1219	1018	42	50	1093	900	30	29	888	851
16	44	40	981	1235			7551	6880			2700	2518			1177	988	10	13	1063	895	1	1	862	844
17	87	79	987	1294	16	17	7843	6948			2628	2433			1129	962			984	879			847	839
18			1078	1451	34	34	8029	7552	T.	T.	2579	2331	T.	T.	1084	942			915	846	9	10	860	851
19	1	1	1446	1656	18	18	8031	7997			2515	2255			1063	920			887	811	4	6	869	863
20			1503	1726	4	4	7570	8090			2425	2164	3	4	1077	922			854	785			851	855
21	4	3	1613	1680	7	8	7162	7610			2337	2082	14	12	1072	907			837	769	T.	T.	840	851
22	T.	T.	1715	1550			6622	6800			2272	1985	7	7	1090	907	8	8	850	766			839	848
23	32	29	1805	1477			6090	6389			2187	1913	2	2	1077	889	34	36	964	840			836	849
24	20	18	1834	1554			5727	5088			2115	1845	4	3	1104	907	3	4	909	810	29	28	896	883
25	T.	T.	1967	1647			5601	6012			2052	1788	56	54	1217	968	2	2	867	800	88	86	1272	1094
26	2	2	2192	1755	T.		5558	6457			1989	1719	92	89	1544	1137			845	800	T.	T.	956	908
27			2880	1895			5385	6669			1936	1664	21	20	1494	1146			821	785			912	951
28			3100	2066			5107	6435			1869	1594	T.		1249	1067	T.	T.	784	761			900	923
29	45	44	4191	2685	2	2	4838	5941			1800	1541			1184	1015	T.	T.	786	752	9	8	922	922
30	28	28	4228	2723	T.	T.	4626	5397			1736	1493			1131	975			765	730	6	6	916	918
31							4333	4993							1096	942			750	718				
1916																								
1			1145	1347			4198	3103			3010	3263			1288	1071	2	1	1627	1272			1020	961
2	T.	T.	1129	1324	T.	T.	3621	2993			2846	3032			1244	1052	18	16	1406	1171			984	932
3			1106	1347			3463	2864			2735	2857			1219	1023	30	33	1596	1272	18	18	1019	933
4	51	51	1091	1374			3916	2952	10	8	2693	2728			1207	996			1428	1205	3	4	990	934
5	9	8	1127	1400			4817	3390			2586	2589	T.	T.	1209	987	47	54	1383	1224	39	46	1129	1015
6	T.	T.	1112	1425			6067	4035			2507	2457	T.	T.	1178	963	29	32	1450	1262	6	8	1079	1009
7			1065	1414			7312	4062			2456	2337	T.	T.	1169	950	7	6	1468	1238	T.	T.	991	965
8			1063	1422			8214	5262			2395	2242	18	21	1232	983			1323	1151	4	4	954	923
9			1161	1471			8889	6075			2330	2141	120	131	1679	1228	6	6	1256	1098	38	34	1067	972
10			1316	1584			9534	7290			2253	2097	12	14	1452	1123	2	2	1213	1054	2	2	1032	973
11	9	10	1546	1699			9697	8639			2185	2014	T.	1	1339	1101	5	2	1153	1005	33	33	1141	1031
12	6	6	1768	1760			9292	9253			2144	1923	1	1	1324	1067	10	10	1191	1009			1046	988
13	32	30	1776	1782	8	7	8635	10157			2099	1862	13	22	1354	1080	26	26	1229	1032			1012	973
14	2	3	1652	1729	T.	T.	7942	11255			2021	1779	T.		1291	1082	18	19	1224	1046	T.	T.	997	956
15	T.	T.	1548	1694			7048	10552			1980	1728	46	49	1325	1076	7	6	1214	1034			998	950
16			1604	1749			6292	9432			1922	1675	1	1	1395	1093	2	3	1183	1021			989	945
17			1900	1897	T.	T.	5724	8273			1870	1616	26	25	1373	1100			1129	1000			998	952
18	8	8	2401	1961			5256	7166	T.	T.	1848	1562	2	1	1340	1078			1080	960	6	8	1012	965
19	2	2	2407	1951	22	22	5056	6356			1763	1524	T.	T.	1255	1035			1085	956	T.	T.	1007	959
20			2179	1945	4	4	5012	5850			1740	1486	10	10	1258	1018	12	13	1117	966			992	959
21			2253	1998			4757	5261			1692	1436	4	4	1241	998	2	2	1079	946			994	959
22			2358	2053	1	1	4511	5161			1618	1384		T.	1211	981			1039	937	T.	T.	996	958
23			2807	2148			4328	5031			1598	1345	2	2	1190	968			1027	914	T.		1002	967
24			3291	2227			4107	4851			1564	1303	9	8	1160	941			1032	917			990	961
25	T.	1	3545	2293			3954	4632			1522	1268	40	38	1236	978	5	6	1042	911			979	959
26	2	2	3557	2408			3787	4404			1469	1236	5	4	1276	994			1037	910			976	962
27			3814	2672			3623	4231			1432	1194	9	8	1222	985		1	997	899			969	960
28			4251	2850			3493	4125			1395	1164	55	48	1339	1036			983	882			963	950
29	48	48	4677	2995			3367	3937			1353	1121	1	1	1286	1016	14	18	1013	914			963	950
30	30	30	4504	3128			3238	3736			1329	1097	76	77	1565	1152	56	66	1176	1052	T.	T.	963	950
31							3111	3512					60	66	1809	1309	3	4	1072	1006				

TABLE 66.—*Daily run-off in hundred-thousandths of an inch over watershed and precipitation in hundredths of an inch*—Continued

Date	October				November				December				January				February				March			
	Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1916-17																								
1	42	42	1026	1007			1283	1459			952	1105			770	988			743	952	4	3	751	938
2	12	14	1038	1033			1266	1446	10	10	959	1115	1	1	770	986			749	952	27	26	751	937
3	1	3	908	1011			1261	1427			963	1105	4	4	786	986			749	962	3	4	735	926
4	1	1	963	990			1249	1425			970	1105	T.	T.	792	986			736	968			727	927
5	26	27	994	1018			1243	1415			984	1106			767	986			740	964	4	3	732	937
6	36	37	1517	1319			1234	1413	3	4	989	1114			755	971	14	10	759	972	T.	T.	732	923
7	24	28	1172	1207	16	16	1236	1413			983	1102			760	970	T.	1	747	962			727	907
8	16	18	1172	1205			1212	1390			824	1082			772	986			766	944			719	926
9	38	39	1260	1291			1186	1372			762	1069			781	986			772	938			717	926
10	30	31	1459	1405			1174	1357			753	1056			779	986			772	938	31	32	724	926
11	84	86	2186	2072			1169	1334	4	4	701	1012			770	986			775	938	34	34	727	926
12			1789	1990	T.	T.	1164	1330			732	1008			770	986			763	938	T.	T.	727	926
13	3	3	1530	1767			1155	1305	16	16	714	989	T.	T.	767	986	T.	T.	759	942			727	921
14	72	70	1446	1668			1155	1268	2	2	787	996			756	984	12	9	759	950			723	919
15	T.	T.	1348	1569			1155	1236			820	988	41	40	739	986	T.	1	754	938	12	13	727	924
16			1376	1563			1155	1226			817	1001	42	41	738	986			749	940			717	906
17			1420	1589			1155	1213	2	2	802	1018	T.	T.	741	974	6	6	749	950			710	903
18	18	18	1428	1616			1155	1212			802	999			729	966	36	36	758	960			758	908
19			1496	1624			1155	1212	24	23	802	1017			745	966	8	8	747	949			800	924
20			1495	1593	2	2	1147	1212	1	1	802	1032	85	95	761	986	1	T.	739	938			823	934
21			1470	1582	T.	T.	1122	1212			802	1024	T.	T.	776	986			749	948			855	943
22			1469	1602			1093	1204	3	3	793	1031			759	986	T.	T.	749	954	8	8	792	938
23	13	12	1472	1627			1067	1180	23	24	792	1033	2	2	759	978			741	940			761	931
24	15	14	1468	1628	2	2	1065	1176	7	6	793	1033			747	967	T.	T.	743	944			804	948
25			1405	1583			1028	1156	36	39	786	1033			739	962	T.	1	777	950			866	977
26			1376	1567			983	1147	T.	T.	764	1033			751	962	T.	T.	765	943			825	966
27			1362	1544			993	1129			751	1024			758	959			757	938			851	970
28			1333	1543			980	1123			732	1010			751	970	T.	T.	759	938			1020	1031
29			1318	1532			947	1106			727	1010			753	974							1270	1090
30			1291	1507			945	1105	12	11	730	989	2	2	753	974					10	10	1100	1109
31			1280	1488					4	4	771	998	8	8	759	971					26	25	975	1089
1917-18																								
1	1	1	1072	1033			960	1033			845	1033			783	986			744	951			650	965
2			1048	1031			954	1033	8	8	845	1033			776	986			721	938			652	954
3			1045	1019			952	1033	16	15	862	1046			781	995			713	922			673	980
4			1044	1021			941	1033			856	1037	6	4	773	998			713	926			682	986
5			1042	1023			943	1033	T.	T.	854	1033	1	1	772	998			726	934	1	2	687	987
6	T.	T.	1040	1025			953	1039	4	3	838	1033	6	6	778	986			709	930	3	3	691	1009
7			1054	1010			956	1046	T.	T.	837	1033	6	6	764	986	11	11	719	932	8	8	691	1013
8			1048	1021	6	6	958	1057	T.	T.	828	1032			774	986			726	938	92	89	689	1033
9			1055	1028			923	1035			833	1012	22	21	774	986			707	931			683	1005
10			1057	1019			909	1033			830	1005	5	5	777	986			717	948	T.	T.	697	986
11			1053	1021			909	1045			837	1012	2	1	763	996			706	950	2	2	706	1008
12			1051	1028			903	1045			831	1017	1	1	773	986			709	954	51	52	724	1032
13			1044	1033	1	1	907	1045			828	993	6	4	768	993	7	6	725	970	24	25	726	1042
14			1051	1033	56	56	914	1055			834	1000	1	1	760	976			708	960			706	1013
15			1044	1036	36	38	929	1069	T.	T.	834	1003	T.	T.	761	974	20	18	712	968			693	987
16			1044	1044			907	1060			805	992	2	2	759	979			706	950			686	986
17	T.	T.	1041	1035	2	1	897	1045			799	989	1	1	739	958			706	940			696	986
18			1014	1044			884	1045			793	985	12	12	756	974	14	14	706	954			698	986
19			1001	1037			872	1051			802	991	3	3	749	974	2	2	706	965	2	1	722	998
20			1008	1033			870	1056			797	988	1	1	735	974			705	952	6	6	742	1023
21			999	1035			875	1041			792	998			700	958	1	T.	706	950	15	14	744	1032
22			991	1045			876	1045			792	990			673	938	4	4	706	966	T.	T.	731	1006
23			984	1042			878	1045			792	986			667	938	4	2	714	994			739	1031
24	6	6	993	1047			883	1049			792	989			723	946	38	37	710	990	1	1	743	1038
25	12	12	1012	1066	5	4	884	1057			792	990	4	5	748	952			708	986	2	2	740	1033
26	T.	T.	1013	1065	1	1	884	1048			790	986	27	26	761	962			702	984			743	1039
27			985	1060			861	1047			792	986	22	24	765	974	106	84	672	986	2	1	752	1057
28	T.	T.	977	1057			846	1035			792	986			749	978			663	984	1	1	743	1061
29			959	1036			862	1033			792	986			743	974					T.	T.	745	1046
30			963	1033			858	1033			793	986	T.	T.	750	976							805	1101
31			960	1033							783	986	2	4	749	982							836	1123
1918-19																								
1	T.	T.	756	796			742	796			727	772			716	750	24	24	685	725			674	730
2	T.	T.	758	796			738	796			727	772			706	748	11	10	685	725			713	742
3			742	796			730	796			727	772			706	748			694	725	22	20	700	748
4			746	796	34	34	751	796			720	772			706	750			695	725			709	748
5			742	796	75	72	772	829			727	766			706	762	6	6	691	732	3	4	697	736
6			751	796	49	46	767	831			736	772			706	771	14	13	685	741			688	741
7	T.	T.	741	796	4	3	759	831	15	15	729	780			699	779	6	6	685	736	6	6	685	736
8	8	8	750	797			759	831	16	16	727	796			702	796			685	733			688	727
9	2	2	765	798			751	814	2	2	727	780			706	776			685	725	6	8	687	725
10	6	6	759	796			741	808			727	772			698	772			685	730			681	725
11			759	796			734	808			720	772			706	771			687	743			680	727
12			751	796			736	800	8	8	722	772	6	5	702	760	8	8	695	748	T.	T.	706	736
13			748	796			731	798			718	772	T.	T.	706	760	4	4	686	748	1	1	723	746
14			737	796			753	808			713	765			699	759			676	748	8	8	710	748
15	T.	T.	748	796	3	4	758	808			722	760			695	748			676	731			691	739
16	8	8	769	801			749	808	20	18	718	760			697	748			675	742			681	736
17	12	14	792	808			738	796	13	11	726	766			695	748			669	738			702	743
18	20	18	795	818			727	796	2	2	717	772			709	754	20	19	674	726			749	767
19	18	16	865	871	24	24	730	796			712	765	1	1	703	752	23	21	681	742			794	812
20	16	16	861	888	13	14	738	803	6	4	717	759			699	748			683	744	10	15	765	795

TABLE 66.—*Daily run-off in hundred-thousandths of an inch over watershed and precipitation in hundredths of an inch*—Continued

Date	April				May				June				July				August				September			
	Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1917																								
1	T.	T.	856	1040	T.	T.	2920	3720	10	10	12842	17782			3332	2824	30	30	1651	1339	T.	T.	1148	935
2	6	6	800	1011	7	8	3221	4309			12368	16417			3206	2665	8	12	1627	1301			1100	924
3			789	1006			[illegible]	4865			14555	16400			3110	2532	2	T.	1576	1254			1070	903
4			775	990	8	8	5263	5117			16360	17869			3009	2419	4	4	1551	1241	T.	T.	1030	879
5			836	1016	42	38	4678	5271	2	2	13658	19652	2	2	2932	2342			1518	1201	T.	T.	1027	883
6	2	2	875	1028	T.	T.	4060	4989			13869	20096	4	4	2844	2279	12	10	1450	1148	1	1	995	881
7			901	1055	2	1	3473	4704	T.	T.	12418	17814	2	1	2777	2164			1424	1113	32	31	1082	934
8			1026	1118	24	21	3172	4323			13066	16859	10	10	2711	2106			1344	1083	2	2	1135	947
9	30	30	1166	1197	32	30	3047	4085			12371	16654	1	1	2675	2085	T.	T.	1317	1080	19	6	1171	948
10	3	4	1071	1227	22	22	3065	3949			11808	16459	5	6	2539	2006	12	13	1353	1065	4	4	1092	938
11	T.	T.	1094	1203	8	8	3099	4072			11372	15289	4	2	2440	1917	16	16	1486	1152	8	8	1114	967
12			1278	1225	2	2	3475	4335			10434	13656			2326	1838	22	20	1573	1222	T.	T.	1067	954
13			1438	1274			4570	4992			9504	11676			2224	1752	4	2	1499	1216	20	23	1134	992
14			1710	1336	T.	T.	8968	6212			8940	10078			2138	1673	T.	T.	1414	1181	1	1	1098	953
15	4	5	1821	1341	12	14	18163	8031			8308	8902			2073	1597	9	9	1367	1139			1067	947
16	52	52	1672	1326			21051	11520			7777	7956			2015	1553	36	40	1524	1175	1	1	1068	940
17	142	140	1507	1302			23099	14268	T.	T.	7340	7206	T.	T.	1947	1510	2	3	1444	1149			1083	942
18	92	90	1358	1252			23602	16181			6926	6683	32	28	1987	1511			1353	1146			1007	984
19	T.	T.	1260	1230	2	4	18295	15861	T.	T.	6546	6160	26	21	2061	1527			1278	1112	4	5	1023	952
20			1227	1249	3	4	14116	13034			6178	5744	6	4	1995	1492	T.	T.	1276	1060	T.	T.	1025	950
21			1395	1387	T.	T.	13872	12564	T.	T.	5833	5370	3	4	1890	1442			1231	1030			1010	986
22			2082	1746	T.	T.	14945	12928			5520	4991			1799	1384	4	2	1193	1011	4	4	1027	952
23			2966	2408	40	37	13238	12633			5218	4672	14	16	1827	1381	1	1	1188	990	12	13	1068	990
24			4280	3151	T.	T.	12703	12143			4918	4336	2	3	1840	1376	1	1	1181	984	6	8	1063	989
25			5705	3899	2	2	12672	12743			4605	4082	30	31	1799	1382			1137	958	1	1	1050	1000
26	T.	T.	6336	4730	T.	T.	11811	12658			4303	3819	4	5	1827	1366			1101	935			1059	1007
27	32	32	5283	4794			14326	12801	1	1	4114	3577	1	3	1739	1360	26	26	1179	965			1054	1018
28	30	67	3712	4545	T.	T.	13495	13610			3874	3366	16	21	1758	1376	1	1	1193	976			1057	1016
29	100	95	3088	4202	T.	T.	15010	14715			3691	3169	28	32	1804	1433			1131	966	T.	T.	1053	1018
30			2770	3740	1	1	15155	16689			3484	2994	2	2	1771	1419	10	6	1125	951	6	6	1057	1023
31					24	22	13427	17950							1634	1330	10	9	1190	965				
1918																								
1	1	1	817	1157	T.	T.	1440	1080			1174	1135			655	739	T.	T.	604	635	3	2	657	706
2	1	1	843	1174	T.	1	1437	1092			1136	1112	15	16	661	725	42	56	668	689	2	2	637	702
3			851	1172	T.	T.	1518	1117	T.	T.	1133	1105	38	31	815	776	T.	T.	663	699	28	29	720	756
4	2	2	808	1133	T.	T.	1532	1130	T.	T.	1129	1098	1	T.	769	770	2	2	638	693	10	10	721	763
5	1	1	792	1096	T.	T.	1617	1139	T.	T.	1118	1079	24	32	767	790	T.	T.	619	661	7	6	697	754
6			801	1067			1679	1168			1099	1066	2	2	761	800	6	4	627	679			662	736
7	T.	T.	798	1047	T.	T.	1586	1198	T.	T.	1091	1043	33	31	809	840	2	2	610	668			656	712
8			892	1084	1	1	1617	1211	T.	T.	1076	1038	10	10	776	822	T.	T.	597	653	41	42	739	758
9			964	1128			1580	1226			1059	1023	30	32	852	858	24	29	670	695	102	106	1192	1000
10	T.	T.	924	1113	T.	T.	1500	1242			1050	1005	6	8	799	844	20	20	665	705	64	64	1649	1227
11	8	9	1015	1158	1	1	1438	1208	T.	T.	1035	996	18	18	787	842	T.	T.	644	698	T.	T.	1051	1073
12	49	48	1006	1161			1375	1164	16	16	1004	992	19	20	899	886			593	666	T.	T.	866	925
13	6	6	984	1204	T.	T.	1365	1167	3	2	1014	976	20	22	858	885	56	57	754	758			807	865
14	T.	T.	956	1206			1338	1203	6	2	1018	940	65	66	855	887	54	54	940	855			765	833
15			938	1191			1309	1181	16	20	986	950	40	38	1288	1035	1	1	698	760			745	810
16	T.	T.	970	1163			1304	1180			924	915	5	8	953	965			659	712	36	44	805	856
17	T.	T.	1027	1107			1291	1208			896	888			791	872			627	689			797	886
18			1019	1087			1287	1217	2	1	873	876			729	799			612	668			763	846
19	2	2	973	1036			1268	1244	12	5	908	868	1	1	702	776			606	657			755	824
20			991	1013	T.	T.	1266	1264	14	14	892	883	5	4	735	780	T.	T.	596	647	T.	T.	751	828
21			1000	1008	T.	T.	1263	1310	5	4	908	889	T.	T.	725	782	31	32	673	702			752	813
22			1035	1049			1240	1309	12	10	938	905	8	8	716	782	16	22	706	747			751	806
23	T.	T.	1150	1099			1219	1285	15	16	898	880	1	1	694	757	T.	T.	665	716	14	13	772	810
24			1292	1155			1210	1261	1	1	866	875	28	24	728	776	T.	T.	608	687			759	808
25			1421	1163			1213	1231	8	6	843	866			700	772	T.	T.	602	674			744	808
26	T.	1	1504	1167			1188	1219			815	838			647	743	T.	1	599	666	T.	T.	752	808
27	1	1	1464	1138			1175	1208			765	795	1	2	648	738	2	1	596	655			752	806
28			1421	1126			1175	1191			726	764	T.	T.	633	717	10	11	636	671			755	796
29			1429	1107	T.	T.	1173	1163			716	754			620	681	6	7	656	693			755	796
30	T.	T.	1381	1075	12	11	1181	1154			675	732	4	4	603	655	T.	T.	631	679			745	796
31							1220	1166					8	7	624	653	33	35	663	698				
1919																								
1	T.	T.	877	950			7092	4462	2	2	4393	4175	18	11	1737	1336	10	11	1377	1074			819	870
2			996	998	19	22	7623	5107			4163	3903	8	8	1770	1323	17	23	1361	1104			787	858
3	T.	T.	989	1005			7386	5582	T.	T.	3955	3686	24	20	1747	1319	3	3	1310	1096			763	839
4			1140	1113			7682	6017			3732	3448	T.	T.	1695	1302	T.	T.	1235	1050			756	833
5			1299	1256			8775	6557			3510	3202			1601	1253			1191	1017	8	7	779	852
6	35	34	1179	1264			9549	7224	T.	T.	3327	2986	16	17	1588	1236	T.	T.	1154	998	8	8	845	890
7	4	4	1022	1152	8	6	9368	7874	T.	1	3214	2802			1543	1212	T.	T.	1109	1008	3	3	850	890
8	22	20	946	1095			8666	8019	52	56	3310	2756	T.	1	1514	1179	T.	T.	1136	975	2	3	837	892
9	10	8	878	1033	12	14	7996	7612	4	4	3202	2647			1479	1154	2	2	1125	978	T.	T.	798	905
10			883	1030	6	8	7654	7060	T.	T.	2991	2497			1461	1108	10	6	1103	950			787	867
11			1063	1165			7256	6879			2864	2369	8	7	1482	1093			1067	949	12	16	768	870
12			1092	1279			6914	7086			2750	2272	52	52	1551	1120			997	920	18	23	850	919
13	T.	T.	1469	1564			6833	7307	T.	T.	2638	2179	21	21	1744	1205			976	928	56	60	988	998
14			1482	1664			7125	7836	T.	T.	2573	2092	57	52	1811	1246	12	14	1018	950	1	2	918	964
15			1412	1655	T.	T.	7294	9105	1	1	2495	2027	88	84	2036	1356			998	925			847	952
16			1452	1652			7136	10754			2440	1971	12	19	2041	1341	1	1	953	910	T.	T.	851	926
17			1618	1734			6843	11259	8	8	2393	1921	1	1	1636	1262			942	909	6	6	854	923
18			1982	1962			6721	11097	2	2	2343	1869	4	3	1535	1194	T.	T.	934	904	4	8	868	916
19			2521	2291			6522	10576			2283	1815	22	22	1569	1187	6	8	919	906	12	14	893	922
20			3182	2308	T.	T.	6414	9753	2	2	2219	1756	T.	T.	1496	1161			573	896			870	918

TABLE 66.—*Daily run-off in hundred-thousandths of an inch over watershed and precipitation in hundredths of an inch*—Continued

Date	October				November				December				January				February				March			
	Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1918-19																								
21	T.	T.	844	887	T.	T.	738	796	1	1	717	748			695	748	32	28	674	730	94	82	755	796
22			792	865	14	16	738	796	24	23	713	763			695	748	1	1	675	744	40	36	731	787
23			763	834	14	14	738	796	1	1	706	768			695	748	8	8	685	738	14	10	706	775
24	4	5	772	831	16	16	738	796			699	753			695	748	6	6	687	732	30	29	701	767
25	T.	T.	780	831	7	7	736	796			695	748			695	748			678	729	T.	T.	704	761
26			748	822			727	796			701	748			689	748	1	1	682	729			709	765
27			739	808			727	796			707	748			685	740	22	19	683	743			706	774
28	12	11	762	820			729	784			712	748			683	736			671	747	20	22	718	774
29			755	813			738	782	2	2	717	748			686	729					2	4	760	835
30			741	808			729	772	78	78	724	748			694	725					T.	T.	842	888
31			741	797					4	4	727	765			685	725					5	4	829	884
1919-20																								
1			871	902			866	903			842	905			790	865			759	843	2	1	759	843
2			866	896			868	893			834	903			781	855	12	10	758	843	22	22	759	852
3	5	6	878	901			870	903			834	903			781	855			750	841	T.	T.	759	851
4			884	906			866	896	T.	T.	833	903	28	28	781	857	54	52	758	842			743	847
5	6	5	885	906	T.	T.	868	903	42	40	828	903	4	4	781	864			749	835	6	5	738	853
6	T.	T.	897	903			853	901			834	907	10	10	781	855			749	834			738	843
7	71	69	915	920	56	56	850	897			834	903	16	14	781	861			749	837			733	834
8			983	984	54	54	866	915	20	21	834	908			768	843	47	48	750	843			724	833
9	1	1	942	961	17	18	866	912			826	894			759	831			750	843	T.	T.	741	839
10	T.	T.	932	960			857	903			813	891			759	842			758	835	16	19	749	843
11			919	938			857	903	T.	T.	813	889	T.	T.	759	836			749	845	T.	T.	744	848
12	10	8	932	955			845	901	23	18	819	889			763	847			751	834			738	849
13	T.	T.	908	943			835	891			808	892			759	840			758	831			756	879
14	T.	T.	899	938			834	890			800	877			759	841			747	835	T.	T.	780	903
15	2	3	902	932			834	891			796	867			759	843			738	825			761	895
16			874	910			840	880			798	867			759	851			738	827	T.	T.	753	901
17			875	903			834	887			792	869			759	853			736	831	11	8	759	910
18			873	904			834	898			792	879			759	834			730	830	6	4	757	905
19			869	901	6	5	849	903			792	871			759	843			742	825			775	944
20			863	901	23	20	849	904			789	867			767	852	8	8	749	828			838	1032
21			865	893			845	900			792	867			770	845	8	9	752	831	13	14	898	1162
22			864	882			827	881			792	867	T.	T.	770	855	15	16	764	856	44	46	881	1213
23			868	891			826	891			792	867			763	843	2	2	781	862	22	24	857	1164
24	27	28	883	905			825	891			787	867			759	839	3	2	772	853			830	1106
25	38	38	913	938	1	1	834	891			792	867			759	840			762	842	T.	T.	808	1076
26	33	37	898	938	122	126	837	899			792	867			759	837			759	831	26	24	807	1070
27	T.	T.	893	938	140	135	851	914			792	867			759	854			759	831	17	16	818	1065
28			866	912	68	60	838	915			792	867			759	849	1	1	758	837	T.	T.	798	1043
29			868	903			840	915			792	867			759	858			751	837			775	1039
30			876	903	T.	T.	834	903			792	862			759	847							775	1019
31	4	4	866	905							792	867			759	843					8	6	797	1022
1920-21																								
1	1	1	1024	1130			992	1203			911	1177	T.	T.	868	1106	T.	T.	834	1045			1047	1528
2			1023	1129			974	1203			925	1168			866	1103			834	1036			1062	1685
3			1023	1121			973	1211	4	3	931	1167			866	1093			837	1044			1159	1899
4	T.	T.	1014	1116			968	1202			913	1163	T.	T.	866	1098	15	16	845	1043	18	18	1170	2119
5			1019	1126	47	46	980	1205	4	3	909	1165			866	1093	13	12	843	1052	T.	T.	1100	2233
6	T.	T.	1022	1120	76	76	995	1215			909	1141	2	2	870	1093	12	12	834	1050	T.	T.	1051	2272
7			1022	1114	58	55	1004	1213			909	1132	T.	T.	866	1088	T.	T.	834	1052	1	1	1023	2243
8			1021	1120			1005	1235			909	1150	T.	T.	866	1087			826	1047	T.	T.	993	2103
9			1027	1127			1020	1224			908	1129			866	1076			822	1036			949	1966
10	4	4	1016	1135			1010	1226			904	1114			866	1068			819	1032			919	1863
11			1012	1126	3	4	1014	1224	6	6	907	1134	2	2	866	1061			855	1102			923	1814
12			1018	1116			996	1221	58	72	914	1156	4	4	866	1068			864	1144	T.	T.	917	1825
13	26	24	1015	1137	T.	T.	988	1213			905	1137	4	4	866	1059			858	1144	T.	T.	926	1832
14	26	24	1059	1281			972	1201			909	1138			854	1057	2	2	856	1146	2	3	929	1848
15			1057	1204			963	1180			891	1115			859	1084	14	15	866	1116	22	22	936	1867
16			1041	1186			963	1173			890	1113			858	1125			840	1105			970	1887
17			1031	1191			963	1186			904	1122	T.	T.	856	1107			834	1090			1052	2025
18	T.	T.	1024	1191			959	1190			902	1124	38	38	863	1093			834	1087			1129	2189
19	68	68	1027	1210			963	1189	15	15	888	1109	35	36	866	1091			827	1071	20	20	1134	2425
20	59	61	1045	1212			967	1203	40	36	905	1133	12	12	866	1096	4	3	824	1058	6	6	1108	2063
21	T.	T.	1029	1202			963	1196	6	6	909	1129			857	1093	T.	T.	824	1058			1118	2776
22	T.	T.	1022	1201			957	1207	T.	T.	894	1141	2	2	847	1081			824	1056	4	4	1165	2851
23	10	7	1013	1197			955	1198			881	1138	35	35	856	1086			834	1178			1185	2845
24			1000	1205			944	1182	8	7	879	1137			856	1097			875	1311			1200	2827
25			995	1234	1	1	941	1200	8	7	888	1129			846	1080			907	1364	26	24	1232	2920
26			1006	1218			933	1189	T.	T.	878	1108			836	1089			936	1398	10	10	1255	2970
27			999	1208	4	4	931	1193			868	1105			836	1067			978	1463			1258	2859
28			993	1204			931	1165			877	1105	2	2	850	1069			1024	1508			1250	2708
29			993	1187			922	1166			877	1105			846	1069							1250	2555
30	106	104	1007	1214			913	1182			877	1105			835	1066					T.	T.	1252	2394
31	46	46	1014	1213					T.	T.	877	1107	T.	T.	834	1054							1256	2293
1921-22																								
1	18	18	1118	1292			1030	1230	5	4	968	1185			909	1141			728	1100			866	1096
2			1107	1280			1023	1230	15	15	973	1198	56	54	920	1171			739	1103			860	1084
3			1088	1269			1001	1252			961	1170	62	58	938	1172			741	1093			869	1090
4			1077	1246			998	1255			925	1122			946	1133	4	4	766	1103			868	1103
5			1073	1255			984	1257			912	1098			923	1145	7	6	784	1099	18	19	866	1112
6	14	16	1100	1301			976	1257			912	1062			913	1145			792	1098	T.	T.	866	1094
7			1082	1298			979	1267			900	1010			909	1131			793	1093			865	1095
8			1067	1276			975	1242			854	1031			909	1131	8	6	816	1100	11	12	862	1093
9			1050	1274			975	1221			840	1030			909	1140	6	4	848	1106			858	1084
10	T.	T.	1057	1281			962	1213			882	1038			909	1149	8	8	861	1113			855	1090

TABLE 66.—*Daily run-off in hundred-thousandths of an inch over watershed and precipitation in hundredths of an inch*—Continued

Date	April				May				June				July				August				September			
	Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1919																								
21	94	82	3919	2846	T.	T.	6275	9024	T.	T.	2167	1714			1408	[illegible]			870	865			854	899
22			5188	3134	33	36	6398	8351	T.	T.	2093	1667	T.	T.	1364	1077	T.	T.	843	869			863	897
23	42	42	6969	3438	6	5	6379	7768	6	7	2085	1637			1326	1049			823	864			872	904
24	19	18	5944	4120	2	2	6148	7223	T.	T.	2026	1592			1310	1028	T.	T.	821	858			873	908
25	37	39	5791	4539	T.	T.	6091	6808	T.	T.	1946	1543	18	22	1347	1036	1	1	806	859	T.	T.	877	898
26	8	14	5180	4609	16	16	6007	6422	6	6	1928	1509	1	2	1330	1024	2	3	822	862			881	898
27	22	23	4556	4506	1	2	5626	5959	T.	T.	1874	1475	T.	T.	1292	1011	T.	T.	826	869	8	8	886	891
28	10	10	4225	4281	10	10	5337	5475	4	2	1855	1440	40	52	1409	1059	T.	T.	807	864	5	5	910	909
29			4336	4103	8	8	5138	5084	T.	T.	1781	1404	2	2	1359	1045			776	850	T.	T.	886	903
30			5578	4183	2	2	4892	4724	T.	T.	1758	1362	14	16	1370	1060	8	8	772	831			876	900
31					T.	T.	4680	4435					27	29	1403	1072	30	27	850	868				
1920																								
1			798	1018			2368	3207	T.	T.	11140	11486			1998	1814	28	32	1482	1265			949	994
2	3	3	785	1014			3351	4119			9883	9934	T.	T.	1947	1773	2	2	1427	1252			910	983
3			788	1009			4577	4896	T.	T.	8782	8868	1	1	1930	1744	3	2	1353	1211	T.	T.	911	989
4			771	992			5404	5280	T.	T.	7879	7702			1880	1702	T.	T.	1328	1186	T.	T.	930	998
5	T.	T.	777	1014			6308	5731	2	2	7136	6872			1793	1657	10	10	1300	1192	23	21	1043	1069
6			878	1132			6906	6330			6472	6214			1749	1618			1272	1170	21	21	1072	1100
7			1038	1399			7292	7055			5804	5590			1701	1575			1195	1138	T.	T.	1064	1096
8	T.	T.	1096	1647	T.	T.	7098	8093	T.	T.	5307	5111			1667	1537	6	6	1222	1143	10	14	1076	1127
9			1295	1998			9387	9307	18	18	4957	4690	1	1	1642	1514	8	8	1287	1155	8	8	1069	1110
10	9	10	1248	2134	T.	T.	9895	9856	2	2	4657	4367	68	21	2024	1533	T.	T.	1227	1127			1020	1097
11	3	4	1111	1958	T.	T.	8515	9781	T.	T.	4276	4073	3	2	1660	1528			1147	1083			997	1105
12			1097	1901			8100	9333	T.	T.	3990	3773			1702	1509	5	6	1176	1089			986	1112
13			1254	2102	48	50	8386	9181	T.	T.	3755	3553			1619	1445	1	1	1197	1085			971	1105
14	T.	T.	1264	2324	89	91	8317	9204	2	2	3501	3347	1	1	1579	1463	4	4	1134	1081			908	1121
15	4	4	1382	2422	12	12	7460	8357			3380	3157	1	1	1543	1411	4	4	1135	1084			962	1086
16	41	40	1321	2477	6	9	6931	7485			3210	2995	9	8	1579	1402	T.	T.	1135	1079			956	1059
17	46	41	1303	2392			7215	7213	1	2	3064	2856	2	2	1563	1404	10	9	1122	1089	4	4	993	1089
18	T.	T.	1307	2271			8598	7940			2952	2727	1	1	1547	1388	T.	T.	1133	1085	T.	T.	997	1061
19	T.	T.	1229	2120			12719	9144			2791	2612	26	22	1534	1370	3	3	1147	1097	T.	T.	992	1076
20	14	14	1212	2038			16502	11101			2684	2492	2	2	1504	1353	10	9	1168	1110	18	16	1023	1098
21	14	14	1170	1969	57	58	18496	16571			2584	2382			1421	1295	2	2	1139	1089	24	26	1083	1149
22			1122	1886	2	2	20943	24091	T.	T.	2497	2294	T.	T.	1399	1279	T.	T.	1091	1061	10	10	1047	1132
23			1128	1870	3	3	22692	30971	T.	T.	2403	2221			1380	1274			1042	1040	26	26	1142	1210
24	6	6	1188	1902			22070	32105			2308	2144	72	82	1614	1439	2	2	1012	1022	22	25	1065	1173
25	76	68	1189	1934	T.	T.	21208	29062	T.	T.	2231	2075	3	4	1523	1368	8	4	1037	1034	9	10	1138	1244
26	7	6	1165	1941	18	20	20204	26996	58	58	2480	2157	8	8	1480	1325	1	T.	1027	1031			1050	1164
27			1160	1926	4	6	18635	23619	26	30	2416	2148	2	2	1445	1318	1	1	999	1025			1084	1146
28	T.	T.	1270	2004			16572	19067	1	2	2257	2046	T.	T.	1405	1265			964	1004			1033	1124
29			1445	2157			15265	16577	T.	T.	2145	1960	18	8	1480	1264			964	995			1027	1120
30			1939	2563			13851	14744	T.	T.	2078	1893	2	1	1438	1264	T.	T.	940	991			1027	1118
31							12377	13085					4	2	1391	1232	T.	T.	942	986				
1921																								
1			1380	2278			3217	3918			6219	5424			2006	1945	T.	T.	1462	1313	18	16	1307	1325
2			1557	2349			3965	5166			5729	4941			1948	1894	2	4	1412	1279	T.	T.	1256	1308
3	T.	T.	1813	2533			4634	6554	33	33	5404	4633	T.	T.	1890	1836	10	10	1424	1300			1171	1259
4	18	17	1998	2728			5424	7729	50	48	5385	4535	28	28	2027	1886	10	9	1401	1294			1141	1223
5	8	8	1945	2692			6003	8753	25	27	5032	4275			1905	1800	T.	T.	1389	1269			1114	1202
6	8	8	1742	2635	20	22	6669	9424	19	19	4681	3932			1843	1746	2	2	1336	1243			1100	1189
7	2	2	1572	2527	1	1	6766	9143	18	18	4709	3827	T.	T.	1812	1712	2	2	1318	1237	T.	T.	1104	1201
8			1439	2334	T.	T.	6584	8864			4327	3555			1744	1639	1	1	1329	1241	T.	T.	1089	1191
9			1379	2194			6473	8534			4150	3413	6	4	1757	1657	34	24	1454	1282			1062	1175
10			1402	2140			6684	9162			4058	3392	T.	T.	1709	1624	4	4	1397	1264			1052	1164
11			1514	2217			7251	10053	1	2	4015	3447	6	6	1699	1610	T.	T.	1352	1240			1044	1175
12	4	4	1621	2197	T.	T.	7811	11634	4	3	3931	3455	12	10	1716	1612	1	1	1303	1213	T.	T.	1046	1179
13			1870	2199	T.	T.	8015	13581	4	5	3826	3487	6	6	1660	1594	19	21	1349	1268	T.	T.	1044	1163
14	8	10	1809	2240	3	4	7934	14647	8	8	3730	3517	24	21	1703	1590	18	16	1416	1316			1028	1160
15	30	34	1760	2155	30	30	7675	14088	3	3	3589	3460	16	16	1703	1585	10	10	1308	1298	4	3	1053	1198
16			1694	2186	42	42	7671	13616	T.	T.	3408	3313	44	42	1844	1631			1316	1250	T.	T.	1063	1201
17			1593	2155	4	4	7305	12426	T.	T.	3245	3178	4	4	1700	1549			1244	1210			1048	1180
18			1661	2177	81	82	7127	11292			3087	3021	33	44	1691	1582	10	8	1281	1223	20	21	1112	1244
19			1693	2225	1	1	7020	10125	T.	T.	2955	2920	32	19	1784	1517	20	20	1337	1286			1082	1209
20	T.	T.	1824	2268			7156	9645	2	3	2905	2833	T.	T.	1664	1471	25	25	1379	1342			1073	1198
21	T.	T.	2049	2268			7062	9510			2789	2728	9	10	1662	1468	10	10	1383	1345			1071	1206
22			2447	2604	T.	T.	8396	9231			2679	2600	24	24	1711	1522	16	18	1350	1346			1090	1213
23	12	11	2884	3008	64	60	9395	9391	4	6	2584	2511	36	34	1734	1539	47	50	1364	1408			1089	1213
24	68	62	2768	2987			9314	9661			2492	2387	13	16	1703	1536	2	2	1444	1384	12	14	1098	1243
25	1	T.	2478	2997	1	1	9117	9510	1	1	2421	2328	23	24	1605	1488	11	11	1325	1323	1	1	1101	1237
26	T.	T.	2132	2809	T.	T.	9396	9061			2334	2247	9	9	1716	1514	T.	T.	1276	1290			1064	1228
27			1909	2566			9026	8500			2255	2171	2	2	1572	1440			1230	1250			1079	1231
28	T.	T.	1941	2429	4	4	8428	8294	T.	T.	2196	2099			1509	1367			1211	1227			1079	1234
29			2080	2300			7811	7548			2117	2057	1	1	1482	1342	T.	T.	1177	1213			1078	1228
30	T.	T.	2607	3148			7262	6731	1	1	2070	1998			1450	1314	7	8	1172	1210			1080	1238
31							6731	6025					5	6	1461	1326	50	43	1348	1312				
1922																								
1	64	68	961	1409			5335	6300	T.	T.	6476	7205	10	13	1960	1882	18	18	1364	1316	36	32	1165	1166
2	1	1	945	1397			5563	6796	6	4	6076	6514			1886	1815	T.	T.	1326	1272	5	4	1151	1160
3			1006	1601			5841	7063	T.	T.	5661	5027			1788	1735	4	4	1278	1240	6	6	1141	1158
4			1156	1700			6094	7401	T.	T.	5372	5423			1726	1653	30	32	1311	1270	10	9	1149	1137
5	6	5	1178	1843			6576	8555			4968	4998	T.	T.	1680	1609	4	4	1337	1271			1070	1102
6			1141	1866			7697	10024	4	3	4624	4669	1	1	1650	1577	T.	T.	1276	1216			1029	1079
7	T.	T.	1104	1820	T.	T.	7942	11674			4338	4302	T.	T.	1595	1539	6	8	1267	1223			998	1063
8	6	7	1123	1893	32	34	7602	12853			4079	4042			1525	1507	2	5	1281	1219	4	4	1008	1075
9	21	23	1135	1989	122	126	7219	12075			3379	3802	T.	T.	1520	1444	40	26	1372	1252			996	1055
10			1078	1922	65	66	6595	10199			3097	3562			1460	1409	3	4	1330	1230			969	1024

TABLE 66.—*Daily run-off in hundred-thousandths of an inch over watershed and precipitation in hundredths of an inch*—Continued

Date	October				November				December				January				February				March			
	Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		recipitation		Run-off		Precipitation		Run-off	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1921-22																								
11	7	6	1067	1287			971	1294			917	1057			909	1140			874	1124	18	16	858	1086
12	2	2	1053	1284			974	1240			931	1097			904	1124			878	1117	31	29	866	1095
13	T.	T.	1083	1257			972	1253			918	1136			896	1135	T.	T.	868	1103			885	1095
14			1026	1291			974	1254			910	1133			896	1149			866	1087			882	1096
15	T.	T.	1029	1288			985	1244			909	1091			895	1131			857	1071			887	1136
16			1027	1284	T.	T.	996	1212	T.	T.	895	1076			902	1134	T.	T.	859	1063	63	61	893	1145
17			1024	1273	24	24	1002	1231			899	1057	1	1	890	1135			866	1084	86	83	878	1138
18			1013	1267			977	1196	12	10	875	1024	18	19	902	1140	1	1	866	1118	26	26	866	1138
19			1026	1274			961	1215	27	25	909	1100	13	12	909	1127			873	1149			870	1154
20			1027	1265			970	1216	8	8	928	1100			909	1136	T.	T.	882	1177			887	1173
21			1029	1266			964	1225	6	6	941	1149			899	1110	34	35	880	1152			945	1177
22			1027	1274			957	1203	52	44	934	1201			873	1087	T.	T.	891	1150			1001	1262
23			1015	1269			964	1213	16	15	933	1187			812	1074	8	8	896	1122			1034	1311
24	29	31	1059	1344	4	4	960	1226			919	1162			741	1085	T.	T.	889	1110	T.	T.	1031	1409
25			1038	1311	4	4	962	1225	4	3	911	1156			682	1075			897	1110			1047	1490
26			1006	1295			953	1196	7	6	918	1163			655	1092	T.	T.	889	1118	7	6	1054	1532
27	8	8	1013	1284			960	1166	5	6	909	1167			630	1084	78	72	887	1117	6	6	1036	1521
28			1003	1251			947	1145			909	1159	12	12	634	1105	1	T.	875	1105	10	10	993	1483
29			1014	1274			948	1154			908	1152			659	1102					T.	T.	967	1445
30			1005	1288			949	1164			914	1166	84	82	666	1099					T.	T.	966	1444
31			1009	1287							909	1156	54	52	702	1116							964	1421
1922-23																								
1			1010	1092			1029	1149			974	1172			931	1080	40	40	888	1044			870	1043
2			1014	1089	T.	T.	1033	1146			973	1169			910	1067			870	1055	12	11	887	1059
3			1020	1091	86	82	1025	1164	10	10	963	1167			907	1042	11	12	877	1038	10	10	902	1070
4			1018	1106	10	8	1041	1185			963	1166			899	1054			877	1035	26	24	890	1007
5	T.	T.	1008	1109			1030	1188			963	1148			899	1052			868	1033	T.	T.	876	1063
6			1021	1103			1016	1178	1	1	963	1143			899	1058			877	1033	1	2	866	1044
7			1022	1108			1001	1164	2	2	977	1158			899	1059			868	1028			869	1067
8			1020	1117			1005	1152	10	10	963	1160			899	1055			869	1037			877	1047
9			1020	1110			1014	1158			963	1135			899	1059	20	18	877	1043	10	11	877	1051
10			1022	1110	4	4	1020	1151			953	1139			899	1041			877	1034	12	14	869	1065
11			1027	1118	15	14	1016	1164			952	1130			900	1045	4	4	876	1024	11	10	877	1037
12	5	6	1028	1156	9	9	1005	1158			959	1122			909	1040	8	8	866	1023	T.	T.	866	1033
13			1023	1137	6	8	980	1139	64	65	963	1138	T.	T.	909	1050			866	1028			856	1028
14			1020	1126			984	1130	18	18	963	1154			918	1043			866	1010	13	14	858	1022
15			1023	1128			976	1115	2	2	963	1152			901	1036			866	1004			864	1015
16	T.	T.	1025	1129	96	97	977	1141	1	1	965	1145			888	1047			874	1014			843	1007
17			1023	1134			1004	1173			952	1129			889	1055			868	1011	16	17	851	1030
18			1022	1132			1000	1162			921	1102			895	1044			880	1013			836	1019
19			1027	1126			986	1174			922	1105			899	1040			900	1016			852	1038
20			1022	1133			975	1166			931	1105	T.	T.	890	1051			905	1027	15	15	854	1062
21	6	6	1022	1141	46	44	983	1189			925	1096			880	1052			892	1028	34	34	866	1039
22			1027	1144	31	30	988	1179			936	1082			888	1050	T.	T.	876	1033	6	5	857	1032
23			1011	1132	20	20	986	1167			941	1091			888	1043			870	1049			860	1023
24			1017	1140	18	17	995	1179			941	1078	20	20	885	1048	T.	T.	877	1041			859	1021
25			1019	1133	T.	T.	984	1167	3	3	941	1100	29	30	877	1060	3	2	877	1053	T.	T.	856	1021
26			1008	1121			976	1169			937	1090	T.	T.	877	1045	10	8	876	1051	2	2	864	1056
27			1008	1141			973	1164			931	1075	T.	T.	874	1054			866	1041			878	1099
28	50	50	1032	1204			973	1167	4	4	932	1089			866	1035			866	1038	T.	T.	890	1158
29	2	3	1028	1189	140	144	986	1190	T.	T.	935	1100			873	1038							931	1261
30	T.	T.	1024	1169	2	2	994	1191			931	1088	10	8	888	1028							980	1308
31			1010	1149					T.	T.	921	1092	22	19	888	1037					T.	T.	981	1447
1923-24																								
1	T.	T.	1185	1252	36	34	1262	1544	5	4	1085	1217	37	40	967	1142			870	1103			872	1066
2	22	24	1273	1395			1269	1520	T.	T.	1071	1210			963	1128	T.	T.	876	1115	14	14	881	1091
3	T.	T.	1260	1363			1237	1479	T.	T.	1070	1200	2	3	958	1145			869	1081	T.	T.	888	1084
4	T.	T.	1246	1363			1212	1446			1070	1202			963	1131			845	1048			879	1061
5	15	17	1293	1422			1186	1440			1063	1205			961	1129			820	1053			876	1067
6			1274	1407			1165	1418			1057	1188			953	1127	3	4	834	1052			866	1095
7			1257	1303			1161	1406			1059	1222			962	1117			834	1080			866	1120
8	18	16	1228	1381	T.	T.	1189	1407	8	8	1052	1200			956	1118			848	1090	16	14	866	1080
9	3	4	1275	1390			1205	1408	10	10	1030	1158	6	6	961	1128			866	1067			862	1066
10	2	2	1259	1302	120	113	1216	1417	20	20	1027	1163			952	1120	62	62	866	1056	5	6	857	1065
11			1244	1384			1221	1447	16	16	1034	1170	4	4	952	1136			870	1062	32	28	866	1068
12	72	72	1249	1476			1189	1424			1041	1176			949	1118			897	1096	69	62	866	1077
13	12	10	1261	1536			1170	1414			1027	1143			936	1112			987	1156	16	12	866	1067
14			1282	1553			1166	1396			1017	1154			931	1112	8	7	942	1123	T.	T.	866	1064
15			1290	1544			1157	1391			1007	1112			935	1102	10	10	947	1127	18	15	866	1047
16			1303	1541			1155	1393			988	1121	10	9	928	1106			951	1105	20	16	866	1058
17			1264	1507			1147	1357			990	1132			918	1090	T.	T.	941	1094	T.	T.	865	1036
18			1239	1474			1134	1341			995	1117			912	1075			912	1099	30	32	857	1035
19			1229	1451			1135	1343			993	1123			923	1079			906	1117	4	4	866	1070
20			1216	1462			1155	1339	11	11	984	1153			896	1054			907	1118	6	6	866	1062
21			1206	1463			1146	1337	T.	T.	971	1136			885	1069			902	1110	22	20	866	1057
22	58	56	1244	1495			1125	1306			956	1130			870	1068	T.	T.	907	1101	6	6	866	1055
23	17	18	1270	1537			1123	1292			950	1106			882	1074	2	2	893	1065	5	5	858	1041
24	20	22	1261	1523			1123	1282			972	1102			880	1088	2	2	877	1082	8	8	856	1056
25	9	9	1246	1522			1121	1279			966	1108			862	1066			868	1076			921	1219
26			1235	1535	10	9	1108	1266	12	12	1000	1145			843	1069	9	8	867	1082			1069	1528
27			1217	1507	6	6	1103	1264	15	13	1003	1131			829	1060	10	10	877	1080	6	6	1186	1762
28			1236	1515			1063	1231			984	1114			822	1073			871	1079	34	32	1054	1439
29			1249	1528			1092	1262	T.	T.	984	1134			821	1078			877	1079	16	15	966	1318
30			1230	1513			1107	1255	30	38	987	1126			824	1080					1	1	938	1244
31	12	10	1241	1525					T.	T.	977	1150			841	1065							905	1207

TABLE 66.—*Daily run-off in hundred-thousandths of an inch over watershed and precipitation in hundredths of an inch*—Continued

Date	April				May				June				July				August				September			
	Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1922—Continued																								
11			1080	1919	T.	T.	5919	8269			3509	3363			1419	1383	4	4	1287	1208			956	1006
12	18	18	1071	1898			5576	7163			3327	3205	2	1	1411	1360			1236	1185			948	993
13	13	14	1053	1874			5549	6877	1	1	3172	3098	T.	T.	1376	1325	31	28	1263	1213			931	987
14			1055	1818			5994	7173			3021	2923			1324	1293	92	75	1725	1586	T.	T.	927	985
15			1111	1950	1	1	7525	7477			2965	2833	T.	T.	1303	1271	18	14	1657	1401			927	1002
16	1	1	1139	2010			8548	8241	2	2	2865	2753			1293	1239	23	21	1451	1359	T.	T.	922	997
17	T.	T.	1083	1964			9629	10201			2771	2649	6	3	1367	1257	1	1	1409	1310	T.	T.	921	991
18			1063	1958			11115	12300	T.	T.	2640	2530	10	4	1356	1276	8	8	1276	1241			964	1027
19			1130	2109	T.	T.	11691	14695			2507	2441			1332	1293	14	18	1340	1297			950	1027
20			1299	2490			11868	17363	T.	T.	2457	2360			1265	1244			1273	1231	T.	T.	935	1017
21			1629	3072	T.	T.	11996	20680	T.	T.	2346	2292	2	2	1257	1228	17	6	1317	1232			929	1019
22			2057	3873			11726	22215	2	1	2269	2208			1220	1191	2	1	1280	1206			927	1021
23			2192	4430			11089	20885	74	74	2508	2375	T.	T.	1176	1185			1202	1170			923	1023
24	T.	T.	2014	5006	T.	T.	10781	19875	1	1	2290	2214	T.	T.	1164	1146	1	1	1169	1144	1	1	928	1087
25	7	7	2037	5399			10322	18263	2	2	2166	2138	T.	T.	1153	1126			1115	1119	12	12	984	1074
26	19	19	2105	5139			9728	16172	1	1	2114	2052	T.	T.	1185	1147			1076	1064	T.	T.	1007	1093
27			2352	5216			8970	13883			2038	1972			1190	1158	2	2	1077	1048	4	2	1006	1102
28	2	3	2378	5136			8321	11975	10	12	1995	1967	20	14	1289	1213	T.	T.	1073	1055	T.	T.	1005	1105
29	4	5	3025	5470			7769	10370	10	9	1982	1926	111	104	1882	1530	32	42	1112	1154			1017	1090
30			4005	6113	T.	T.	7303	9002	9	8	1986	1897	24	22	1485	1375	T.	T.	1095	1103			1015	1100
31					24	23	7047	8076					2	2	1457	1349			1044	1069				
1923																								
1	31	31	968	1426			3649	4223			4234	4668			1498	1323	2	1	1084	1020	22	32	1167	1211
2	11	12	948	1347			4329	4609			3976	4236	T.	T.	1469	1298	2	1	1063	1006	1	1	1106	1126
3	4	4	917	1292			5361	4984			3730	3898	4	6	1469	1315	2	2	1059	1004	1	1	1081	1109
4			904	1256	6	6	6114	5525	T.	T.	3532	3613	32	32	1534	1378	21	22	1140	1065			1047	1066
5			923	1279	14	13	5967	6055			3346	2302	4	6	1483	1349	T.	T.	1135	1050	4	3	1062	1075
6	24	24	1058	1424			5374	6350			3152	3091	1	1	1445	1319			1047	993			1015	1047
7	4	5	1104	1527			5771	6482	22	20	3057	2955	34	34	1505	1386	2	2	1063	1005			970	1021
8			1117	1601			6634	6770	21	20	3053	2887	39	41	1596	1443	10	12	1081	1027	T.	T.	973	1009
9			1168	1680			6923	7558	2	2	2816	2669	25	28	1505	1454	6	4	1133	1064			969	1000
10			1166	1799			7583	8110			2684	2556	18	7	1574	1373	55	57	1322	1205			953	1000
11	T.	T.	1287	2031			8411	8552			2590	2432	2	1	1498	1324	46	46	1216	1160			952	909
12	2	2	1518	2474	T.	T.	8676	8892	2	1	2518	2321			1445	1262	34	36	1243	1203	14	14	993	1048
13			1630	2724	28	30	8362	8991			2469	2218	24	22	1522	1325	20	18	1196	1234	4	4	1002	1067
14	1	1	1480	2658	2	2	7712	8297			2374	2130	16	16	1580	1371	28	28	1276	1225	12	12	1030	1092
15			1386	2460	1	1	7120	8052	1	1	2285	2084			1480	1287	8	8	1263	1237	30	28	1137	1193
16			1491	2427	14	12	6917	8638	2	2	2237	1979	T.	T.	1422	1253	34	28	1435	1334	30	30	1102	1209
17			1721	2534	1	1	7254	9224			2163	1886	T.	T.	1371	1219	43	36	1546	1370	34	32	1142	1251
18	T.	T.	1691	2863			7908	10226	T.	T.	2095	1851	8	8	1378	1204	30	30	1419	1334	105	102	1293	1570
19	16	12	1584	3046			8528	12577			2019	1762	8	4	1368	1197	16	12	1346	1272			1335	1497
20			1711	3021	T.	T.	8791	15105	34	29	2085	1831	28	19	1424	1220	3	2	1297	1242			1315	1366
21	28	28	1677	3034			8550	15921			1948	1733			1368	1185	24	28	1214	1230			1269	1280
22	65	62	1608	2894	T.	T.	7925	14712			1895	1681	T.	T.	1285	1160	1	1	1232	1209	6	5	1201	1247
23			1538	2687			7286	13487			1835	1615			1241	1115	4	4	1183	1182	73	76	1647	1538
24			1565	2593	T.	T.	6718	12094			1786	1574			1206	1080			1138	1123			1473	1448
25	12	10	1572	2549			6361	10660			1730	1517	2	3	1190	1074	T.	T.	1100	1091			1265	1341
26	10	12	1692	2613			6139	9354	22	20	1771	1560	5	5	1213	1090			1074	1044			1185	1299
27	2	2	1685	2757			5871	8214			1683	1476	2	2	1220	1097			1041	1008	36	38	1201	1318
28			1907	2792			5533	7150			1616	1433	T.	T.	1154	1068	T.	T.	1027	1015			1225	1332
29			2486	3198			5222	6256			1584	1405			1071	1033			1045	1020			1225	1305
30	T.	T.	3055	3749			4880	5706			1536	1366			1056	1019	2	2	1062	1044			1211	1277
31							4555	5231					10	8	1085	1029	20	16	1104	1074				
1924																								
1			935	1224			4341	4169			4310	3582			1594	1380	14	12	1179	1135	T.	T.	855	992
2	14	16	917	1231			5536	4854	T.	T.	4078	3365			1551	1350			1118	1093			828	983
3			1140	1397			6518	6025	2	T.	3872	3167			1508	1328	1	1	1113	1081			824	984
4			1351	1479	3	3	7629	7232	T.	T.	3699	3017	10	9	1467	1301	14	14	1122	1089	T.	T.	825	969
5			1745	1670	6	6	8762	8761	T.	T.	3548	2877	34	33	1530	1354	2	2	1149	1091			826	960
6			2267	1883			9294	9408			3415	2759	10	10	1617	1426			1090	1056	14	11	850	1000
7	T.	T.	2349	2020			9400	9499			3308	2666	2	2	1564	1423			1020	1046	1	4	857	1015
8	T.	T.	2288	2242			9657	9626			3182	2576	17	19	1625	1471	T.	T.	984	1008	1	2	825	1022
9	14	14	2075	2281			10233	10327			3053	2482	8	6	1588	1466	T.	T.	1000	1001	10	11	839	1044
10			2030	2359			10757	11486			2967	2390	24	28	1651	1487	17	12	1018	1008	55	60	1078	1192
11	T.	T.	2151	2439			11031	13047			2880	2290	T.	T.	1555	1475	4	4	1025	1011			922	1145
12			2520	2730	T.	T.	10908	13834	3	4	2795	2222			1491	1384	2	2	1005	1014			905	1127
13			3202	3093			10643	15004	6	4	2737	2159			1428	1313	24	28	1056	1093			901	1106
14			4295	3750			10337	17219			2602	2110	T.	T.	1396	1266	19	19	1112	1120			901	1101
15	27	24	4279	4158			10089	18734	2	2	2506	2073	14	14	1424	1250	2	4	1059	1097	T.	T.	887	1083
16	14	12	2845	3961			9684	18267	T.	T.	2453	2005	10	10	1453	1279			1006	1047	26	38	972	1166
17	2	2	2191	3448			9579	17124			2364	1930	T.	T.	1440	1309			976	1022			952	1181
18	T.	T.	1964	3045	T.	T.	9439	15915			2287	1869			1343	1243			952	990			918	1166
19			2080	2895	T.	T.	9178	14560			2200	1812			1268	1187			922	969			956	1155
20			2722	3083	T.	T.	8845	12839			2174	1769			1238	1153			900	953	T.	T.	949	1144
21			4373	3616	T.	T.	8530	11229			2101	1736			1199	1135			890	989			960	1137
22			5145	4215			8114	9643			2059	1677			1166	1103			894	931			969	1143
23			5801	5214			7611	8309			1992	1628	T.	T.	1176	1081			876	934			969	1144
24	9	8	6338	6292	8	10	7133	7207			1912	1590	1	1	1159	1076	13	11	925	970			966	1165
25	20	18	5878	6520	4	4	6607	6307			1860	1539	1	2	1165	1068	T.	T.	927	989	T.	T.	972	1168
26	34	36	4583	6109	17	14	6138	5770			1777	1504	T.	T.	1166	1074			881	982			969	1171
27			3993	5283	18	19	5771	5315			1721	1469	29	28	1201	1134	3	2	874	980			970	1165
28	6	6	3571	4659	9	10	5479	4919	5	6	1710	1463	16	16	1274	1198	2	3	883	996			971	1182
29			3386	4254	5	6	5108	4555			1664	1425	6	6	1223	1157	T.	T.	873	992			981	1186
30	T.	T.	3570	4077	1	1	4855	4242	T.	T.	1640	1413			1180	1128	T.	T.	861	986			983	1179
31							4565	3900					4	4	1185	1133	1	1	854	993				

TABLE 66.—*Daily run-off in hundred-thousandths of an inch over watershed and precipitation in hundredths of an inch*—Continued

1924-25

Date	October				November				December				January				February				March			
	Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1			986	1167			972	1190			900	1074			909	1098			877	1070			866	993
2	1	1	994	1174			973	1193			934	1073	T.	T.	909	1109			868	1056			870	1051
3			1001	1200			968	1184	8	10	960	1081			902	1098			877	1066			876	1067
4			1008	1211			971	1188			944	1095			909	1080			874	1085			892	1091
5			1000	1198	22	20	1000	1192	T.	T.	940	1094			909	1067	T.	T.	873	1091			904	1111
6			990	1209	8	8	995	1237	52	53	950	1063			908	1083			878	1086			902	1148
7	12	11	997	1251			969	1162			962	1110			899	1087	33	32	888	1069	83	74	889	1098
8	T.	T.	1018	1224			989	1146	T.	T.	955	1124			899	1060	1	1	880	1045	133	130	888	1089
9			1012	1214			1000	1168	T.	T.	941	1102	T.	T.	899	1049	12	11	885	1040	12	12	878	1082
10			1027	1216	6	6	984	1208			932	1087	4	3	893	1045			870	1046	2	2	870	1056
11	15	17	1030	1231			963	1181			920	1100	T.	T.	897	1056			868	1060	T.	T.	877	1063
12			1019	1239	22	22	973	1181			924	1104	T.	T.	888	1022			870	1072	11	11	877	1071
13			1016	1243	T.	T.	967	1201			932	1116			888	1050	1	1	866	1072	4	3	877	1050
14	47	54	1062	1326			964	1183			933	1118			889	1031			866	1045			868	1043
15	10	12	1215	1416			963	1166			931	1116	8	8	893	1014	T.	T.	865	1047			871	1041
16			1075	1319			963	1178	50	50	935	1141	T.	T.	882	1017			866	1028	1	2	873	1046
17	26	28	1112	1316			963	1167	52	50	941	1149			875	1005			866	1022	12	11	897	1046
18			1099	1325	47	46	967	1178	17	17	939	1143			866	999			866	1046			884	1018
19			1017	1248	2	3	972	1193			913	1118	T.	T.	866	1016			866	1033			887	1027
20			1001	1207			966	1199			919	1113			866	1028	T.	T.	866	1074			927	1078
21			1008	1201			971	1201			920	1124			866	997	10	10	866	1037			955	1133
22			985	1209			964	1211	8	8	936	1134			866	990	T.	T.	865	1048			973	1180
23			984	1206			963	1171	28	22	937	1147			866	1019			858	1040	2	2	971	1196
24			997	1200	T.	T.	953	1137			917	1122	1	1	871	1040	T.	T.	866	1060			970	1208
25			993	1212			941	1119			909	1105	T.	T.	877	1042			866	1041			1030	1319
26			981	1205			943	1127			909	1105	3	2	877	1039			866	1014			1085	1366
27			968	1200			946	1116			906	1109			877	1035	T.	T.	866	1029	40	38	1022	1270
28			968	1198			952	1126			918	1110	2	1	877	1044	2	2	866	1024			1055	1302
29	50	29	1011	1222			914	1112	T.	T.	920	1125			873	1035							1141	1353
30	1	1	1013	1223			900	1102			920	1123			866	1052					T.	T.	1207	1409
31			977	1211					3	3	919	1123			868	1058							1326	1433

1925-26

Date	October				November				December				January				February				March			
	Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off		Precipitation		Run-off	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1			840	913			838	949			834	920	12	12	802	882	T.	T.	759	804			731	931
2			837	904	80	77	862	990	T.	T.	834	929	22	20	804	898			749	837			735	863
3	T.	T.	858	906	23	22	866	991	2	2	833	901			813	899	T.	T.	727	833			735	878
4	6	6	866	929			865	982			818	850			806	896			727	861	1	1	738	877
5	52	47	1009	1049	1	1	857	963			813	922			794	868			720	880	17	22	746	851
6	T.	T.	928	993	65	62	859	968	2	2	813	927	1	2	792	866			735	797			738	864
7			878	962			866	986	5	6	813	922			792	848			752	824			729	872
8			866	950			866	977	T.	T.	813	908			792	835			763	857			727	909
9			866	942			856	970			802	909			792	848			764	850	26	28	727	890
10	26	24	890	980			856	977			802	911			784	848			763	857	38	40	727	860
11	34	32	1071	1130			865	981			802	908	T.	T.	755	821			762	864			744	924
12	4	4	945	1031			866	984			807	916			749	816			759	825			744	907
13	34	36	947	1144	T.	T.	866	975	2	2	813	920			753	847	2	2	757	836			754	965
14	37	40	941	1124	T.	T.	852	926	T.	T.	804	874			747	825	1	1	759	837			773	985
15			923	1071			834	924			763	814			708	821	T.	T.	755	834			788	985
16			928	1062			834	967			772	851	T.	T.	730	838	13	12	752	836			782	1012
17			915	1054			834	952			783	881			708	842	12	12	744	824	T.	T.	787	1017
18			909	1028			834	947			780	878	T.	T.	729	831			739	820	T.	T.	762	978
19			917	1004			804	923			803	867	12	11	737	793			727	839	22	22	750	987
20			892	989			792	917			796	865	20	18	718	804			727	881	30	34	750	995
21			879	982			804	922			787	869			719	797	T.	T.	733	848	15	10	750	992
22			882	982			826	924			792	854	1	1	673	796			732	845			780	1013
23	38	40	930	1043			834	931			793	864			667	798	8	8	737	835			817	1044
24			909	1011	T.	T.	834	929			792	870	1	1	659	800			735	850			825	1075
25			891	992			834	934			792	856			710	805	2	2	731	829	10	8	795	999
26			877	972			834	930			784	871			715	817			714	888	T.	T.	789	960
27			872	976			828	935			792	878			724	794			712	896	T.	T.	775	921
28			877	980			816	950			787	878			707	788			729	902	2	2	770	893
29	T.	T.	874	974			824	928			764	884			697	811					26	26	767	877
30			853	960			833	919			771	867	2	1	759	824					T.	T.	762	891
31			848	952					T.	T.	792	840			755	798					28	26	787	888

TABLE 66.—*Daily run-off in hundred-thousandths of an inch over watershed and precipitation in hundredths of an inch*—Continued

1925

Date	April Precipitation A	April Precipitation B	April Run-off A	April Run-off B	May Precipitation A	May Precipitation B	May Run-off A	May Run-off B	June Precipitation A	June Precipitation B	June Run-off A	June Run-off B	July Precipitation A	July Precipitation B	July Run-off A	July Run-off B	August Precipitation A	August Precipitation B	August Run-off A	August Run-off B	September Precipitation A	September Precipitation B	September Run-off A	September Run-off B
1	1	T.	1388	1341	T.	T.	2523	3257	T.	T.	1594	1762			1088	1117			826	935	5	2	855	958
2			1411	1354			2533	3718	4	4	1593	1722	16	16	1049	1148	7	9	813	938	4	6	835	941
3			1415	1409			2532	3937	52	55	1627	1842	4	2	1029	1129	34	50	905	1059	T.	T.	818	931
4			1587	1488	12	12	2602	3914	64	66	2224	2156	48	58	1120	1258	18	20	887	1036	22	18	878	975
5	1	2	1753	1530	8	8	2640	3935	12	9	2118	2013	30	32	1272	1324	1	1	874	1012	4	8	856	976
6	24	24	1617	1442	1	2	2624	3839			1835	1934	1	1	1122	1213			820	966	8	6	857	967
7	25	27	1438	1373	1	T.	2607	3724			1727	1720			1041	1147			821	945			834	941
8			1359	1282	6	8	2533	3872			1653	1686	12	14	1026	1141	4	4	815	920			804	928
9			1370	1290	4	5	2446	3890	T.	T.	1611	1583	34	36	1006	1203	34	31	929	1012	7	7	806	942
10			1547	1409	14	13	2398	3803			1592	1526	29	29	1120	1205	54	56	1048	1134			812	986
11			1861	1550	48	46	2750	4029	36	38	1660	1646	11	12	1156	1234	3	3	916	1042	2	1	806	921
12			2196	1700			2670	3704			1611	1564	2	3	1017	1125	12	10	873	1015	17	20	843	957
13			2249	1745			2493	3623			1528	1498	T.	T.	970	1049	3	2	867	979	6	6	851	938
14			2305	1793	1	1	2431	3443			1484	1447			940	1029			829	941	2	2	825	933
15			2379	1849			2408	3238			1451	1405	11	15	939	1027			781	901			810	916
16			2460	1928			2374	3081	8	10	1450	1445	4	3	913	1004			767	883			798	905
17			2436	2059			2344	2985			1411	1401	7	7	899	993	T.	T.	763	863	6	6	825	934
18			2296	2071			2281	2884			1374	1359	9	9	897	999	45	58	857	1024	43	46	905	1027
19			2201	2152			2233	2765	3	2	1367	1348	22	20	855	987	24	28	912	1043	16	16	962	1049
20			2360	2414			2142	2648	4	3	1332	1356	31	30	1019	1102	5	8	860	1000			867	984
21	30	31	2354	2657	11	10	2091	2572	8	8	1314	1361	32	37	1024	1141	T.	T.	824	960	2	4	858	968
22	20	22	2246	2685			2009	2447	2	T.	1263	1335	1	2	997	1084	20	21	810	978			855	931
23	2	2	2078	2304			1945	2315			1240	1286	4	4	931	1042	33	30	938	1098	T.	T.	863	923
24			2090	2104	6	6	1909	2201			1182	1251	T.	T.	903	1005	14	12	952	1127	T.	T.	863	907
25			2131	2080			1861	2129	2	2	1145	1222	3	8	901	1016	17	16	915	1077			861	922
26			2134	2266	T.	T.	1808	2042	2	3	1135	1211	8	8	915	1006			860	1012			860	930
27	T.	T.	2166	2549	T.	T.	1759	1984	12	11	1142	1221	34	33	1007	1093	4	2	849	980			850	917
28			2245	2829			1719	1931	1	1	1136	1194	1	1	944	1034	24	22	878	986			844	912
29	30	32	2255	3023	T.	T.	1660	1854	5	6	1093	1173	10	12	920	1028			891	990			847	911
30	11	8	2447	3109			1638	1801	T.	T.	1088	1170			874	982			830	954			847	910
31					6	6	1616	1795					4	5	843	955	1	1	819	933				

1926

Date	April Precipitation A	April Precipitation B	April Run-off A	April Run-off B	May Precipitation A	May Precipitation B	May Run-off A	May Run-off B	June Precipitation A	June Precipitation B	June Run-off A	June Run-off B	July Precipitation A	July Precipitation B	July Run-off A	July Run-off B	August Precipitation A	August Precipitation B	August Run-off A	August Run-off B	September Precipitation A	September Precipitation B	September Run-off A	September Run-off B
1	40	38	770	879	7	6	3045	3834	2	2	2724	2960	6	6	1367	1203	T.	T.	812	803			646	665
2			767	898	T.	T.	3177	4068	2	1	2676	2840	10	8	1313	1157			796	771	11	12	672	705
3	2	2	770	903	25	23	3349	4351			2621	2681	14	15	1344	1179	34	28	843	817	21	20	700	749
4			810	969	T.	T.	3613	4738			2577	2582	2	1	1317	1173	14	14	881	841	5	6	741	755
5			841	1033	34	36	3759	5355			2528	2455	10	10	1324	1179	1	T.	862	825			709	755
6	T.	T.	894	1089	2	2	4066	6103	3	1	2492	2393	22	21	1389	1218	85	97	1215	1146			690	719
7	T.	T.	956	1242	1	1	4125	6628			2455	2324	9	10	1400	1224	63	66	1229	1083	T.	T.	685	718
8	4	4	928	1213	13	14	4160	7077			2393	2193			1274	1154	2	2	1223	1034	1	1	679	708
9	T.	1	944	1108	1	1	3934	6966	T.	T.	2319	2103			1190	1079			982	939			657	707
10	4	T.	971	1068	14	14	3673	6498			2255	1992			1147	1041	12	6	919	912	T.	T.	645	711
11			1030	1071	3	3	3517	6077	T.	T.	2197	1934	96	92	1697	1300	2	1	931	895	28	26	731	796
12			1074	1153	18	20	3328	5568	25	24	2244	1950	15	6	1404	1191	2	2	918	887			710	770
13	T.	T.	1096	1202	8	6	3293	5110	T.	T.	2138	1869	T.	T.	1266	1112			885	861			683	747
14			1193	1237			3183	4763			2043	1779	2	2	1134	1054	8	7	890	859	T.	T.	660	740
15			1305	1314	12	15	3164	4622			1967	1710	T.	T.	1137	1016	2	2	878	843	3	3	676	742
16			1452	1386	1	1	3244	4591			1900	1634			1103	975	T.	T.	868	827	4	4	677	755
17	T.	T.	1434	1372	T.	T.	3380	4749	5	6	1871	1610			1057	947	T.	T.	856	817	1	1	684	757
18			1546	1444	T.	T.	3521	4955			1843	1575			1036	926	2	2	857	821			673	763
19	16	18	1450	1379			3678	5801			1759	1509			999	894			821	798			673	759
20	70	68	1372	1307			3722	6741			1698	1462	21	26	1041	920			788	770	1	2	676	742
21	2	2	1536	1471	T.	T.	3718	6805			1655	1399	4	6	1035	926	T.	T.	760	763	1	1	688	738
22	T.	T.	1732	1609			3652	6528			1556	1359	T.	T.	988	906	T.	T.	738	751	8	8	704	763
23			1956	1631			3550	6096			1493	1323	T.	T.	958	892	T.	T.	744	745			694	761
24			1995	1594	8	8	3476	5584			1432	1264	2	2	921	917			706	733			685	753
25			2271	1669			3328	4974			1385	1223	2	2	915	901	T.	T.	693	724	2	2	701	759
26			2545	1857	26	27	3312	4587	2	2	1335	1191	T.	T.	890	889			687	716	66	70	897	946
27	12	11	2508	2071	2	4	3240	4145			1307	1180	19.	18	936	931			671	699	8	8	804	870
28			2673	2575	2	3	3072	3798	T.	T.	1289	1158	11	12	948	947	1	1	665	701	T.	T.	784	841
29			2759	2986	T.	T.	2918	3560			1247	1140	12	16	947	939	T.	T.	657	694			786	828
30			2857	3466	12	9	2843	3357	62	53	1419	1218			900	902			650	689	6	8	792	838
31							2783	3145					T.	T.	854	867			646	673				

NOTES ON ESTIMATING RUN-OFF

ABRAHAM STREIFF, C. E.

[115 Second Street, Jackson, Mich.]

The design of works for control of water requires the estimate of future run-off. This is usually done by taking the probability of occurrence a priori equal to that a posteriori, which procedure often based on short records does not take into consideration the oscillations in precipitation which occur. Longer records do not entirely

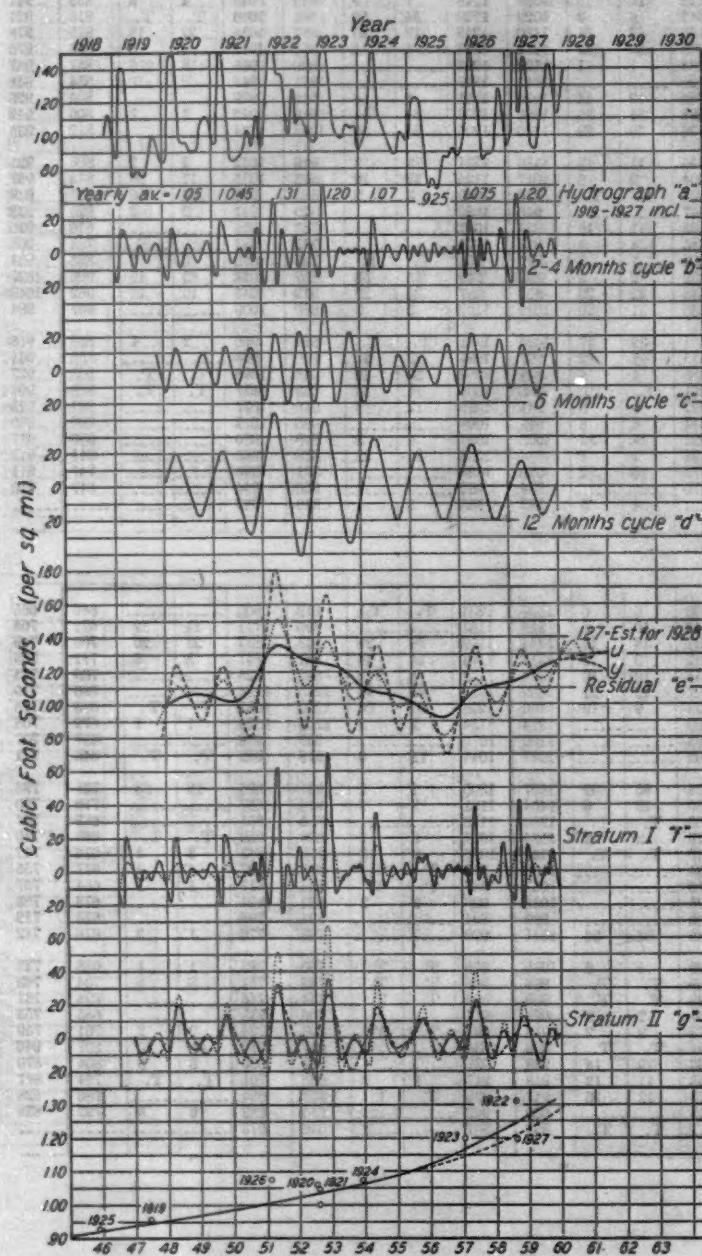

FIG. 1

solve the problem for the existence of long-term trends in rainfall and hence run-off is an established fact. (1) A better procedure is to analyze these trends and oscillations and to estimate their extrapolation for such length of time as may be involved in the project under consideration. Covering shorter periods such estimates have their value for operating purposes. For hydroelectric plants the estimate of next year's output is of value. The water output is of value. The water supply of large cities and the operation of irrigation reservoirs require an estimate of the balance of water receivable into and to be drawn from storage in order to anticipate remedial measures in case of expected depletion.

Precipitation and run-off are, in engineering, usually regarded as chance phenomena. Adoption of such a fortuity theory renders a solution of above problem impossible. It is, moreover, not entirely true. While indeed the short-term variations exhibit some fortuitous characteristics, typical oscillations and trends of longer duration may be isolated from the observations. It is remarkable that run-off, notwithstanding its dependence on a multitude of variable factors such as transpiration, seepage, evaporation, topography and geology, exhibits more regular features than rain-gage data, probably on account of the equalizing effect of large drainage areas and ground storage.

In previous study (2) a method was given suitable for estimating run-off. Application on the Manistee River in Michigan is given in Figure 1. The Manistee River at the point selected has a drainage area of 1,451 square miles It originates on the high plateau of glacial till and overwash which covers the Lower Michigan Peninsula 600 feet deep, and empties into Lake Michigan. In the 12,000 years since retreat of the last ice sheet (3) the river has excavated a deep valley in this glacial till which forms a vast underground storage reservoir resulting in exceptionally even flow (fig. 1) with a maximum range of variation of the yearly average of ± 30 per cent of the mean, which is smaller than usual.

In order to render the hydrograph *a* (fig. 1) suitable for extrapolation, it must be reduced to an equivalent curve of simpler form *e* (fig. 1). It appears that this is possible in the following manner: The monthly averages are added four times and the result reduced to phase and scale dividing by 16 and displacing 2 months. (See Table 1.) The result is now subtracted from column 1 and gives the first stratum, *f*. Then, the first residual (column 5) is again four times added with an interval of 2 months. Thus, if the monthly figures are a, b, c, d, e, these sums are formed $a+c$, $b+d$, $c+e$, etc. This again is repeated four times. The result is again divided by 16 and displaced 4 months in order to reduce to correct scale and phase. (Column 10.) Subtracting column 10 from column 5 gives the second stratum, *g*. An example of the summation is given in Table 1; it may be carried on until the end of the record.

A median line can now be drawn through the oscillations of the first stratum, and it may be seen that this median line in appearance follows the outline of stratum *g*. The difference between this median line and the first stratum, plotted separately, gives cycle *b*.

This median line is now added to the second stratum *g* and a median line drawn through this corrected curve. It may be seen that this median line in appearance again follows the outline of the remaining residual and it is added to this. The difference, with the second stratum separately plotted, gives cycle *c*.

A median line is now drawn through residual *e*, and the oscillations above and below this line separately plotted. This gives cycle *d*.

The original hydrograph is equal to the sum of the 4 elements *b*, *c*, *d*, and *e*. We have now the following remarkable result:

Averaging residual e year by year, we obtain within a few per cent the average yearly flow of the river. The hydrograph is therefore equivalent to residual e in giving the average annual flow.

In other words, the sum of elements b, c and d over each year is practically equal to zero.

A closer inspection of b, c and d shows that d is an annual fluctuation variable in amplitude, but with a constant period of one year, c is a six month cycle, also of variable amplitude and constant period. C and d are so regular in appearance that there can not be any suggestion of fortuity. These oscillations are apparently seasonal.

Cycle b is more irregular oscillation and suggests presence of a fortuitous element. The annual peaks vary from three to five in number. Nevertheless, it offers some regular features. A maximum occurs for instance, in April each year except in the lowest year 1925. It is this cycle which precludes estimate of run-off month by month, although taken over a whole year, the sum is practically zero.

These three cycles are therefore seasonal fluctuations around a mean value expressed in residual e. They do not affect the mean flow of the year.

The hydrograph is now reduced to an equivalent residual e. This residual is of such simple appearance that it may be extrapolated with a certain degree of probability. The following points are here to be observed:

The record, if extending over a whole number of years, is shortened by repeated addition, so that residual c does not extend to the end of the year. It is easily extended because the mean flow for the last year of the record is known and must be equal to the mean of element e over that year.

We know, therefore, the starting point of residual e for the year to come. The extension is aided by several considerations. To begin with, a relation with the Wolf numbers may be established, which for some regions, as this one, is very pronounced. Two maxima appear in an 11-year period, one during minimum and another during sunspot maximum. Also, the observation of Doctor Bauer 4 that it is the rate of change rather than the absolute magnitude of the Wolf numbers which is the important factor, seems to apply to run-off in this region. The maxima in run-off leads the maxima in Wolf numbers somewhat. Hence, we may expect that the extension e for 1928 is not materially higher than 1927. Likewise a low flow in 1928 can not be expected for the same reason and the extension of e may therefore perhaps follow u or y. A further consideration favors both. Superimposed on e are oscillations with a variable period which are about 1.5–1.6 years apart and which should culminate again in the beginning of 1928. Then the annual cycle gives an indication of the extension of c. The minimum in 1927 is located at such a point, that the maximum in 1928 can not be very high (point o), and hence it is unlikely that e will rise abruptly as the amplitude of point o over e is already as small as occurred through the record. On the other hand, the relation to the Wolf numbers precludes the probability of an abrupt decline.

These considerations allow an extension of e with, as previously found, considerable degree of probability, and therewith an estimate of the mean flow for the following year. It may be seen that the extensions may be varied in a considerable range without varying the mean value more than 5 per cent.

The above considerations are based on the existence of a continuity in the mean annual values of run-off as disclosed by residual e. Adopting a fortuitous sequence such estimates as the above become impossible. The estimate has no practical value as an interpretation of next year's rainfall, for the seasonal distribution thereof is, of course, the issue which determines its practical importance. But, for all works involving annual storage of water, the estimate is of value. While of proven reliability in the wet regions its applicability to semi-arid regions has not been investigated.

LITERATURE CITED

1. Alfred J. Henry: Secular variation of precipitation in the United States. Bulletin of the American Geographical Society, March, 1914. C. F. Marvin, in Monthly Weather Review, 1923.
2. Monthly Weather Review, November, 1926.
3. F. W. Sardeson: Beginning and recession of St. Anthony Falls. Bull. Geol. Soc. Amer., vol. 19 29–52.
4. Report of a conference on cycles. The geographical review, October, 1923.

TABLE 1.—*Residuation of Manistee River hydrograph*

Mo. av. run-off c. f. s/sq. m.		1	2	3	4	5	6	7	8	9	10	1-5	5-10
1918												Stratum f	Stratum g
November	1.01												
December	1.13	2.14											
1919													
January	.95	2.08	4.22			1.01						−0.06	
February	.86	1.81	3.89	8.11		1.07						−.21	
March	1.42	2.28	4.09	7.98	16.09	1.21	2.22					+.21	
April	1.34	2.76	5.04	9.13	17.11	1.22	2.29					+.12	
May	1.04	2.38	5.14	10.18	19.31	1.05	2.26	4.48			1.01	−.01	+0.04
June	.75	1.79	4.17	9.31	19.49	.87	2.09	4.38			.95	−.12	−.08
July	.79	1.84	3.33	7.80	16.81	.79	1.84	4.10	8.58		.89	.00	−.10
August	.77	1.56	3.10	6.43	13.93	.78	1.65	3.74	8.12		.86	−.01	−.08
September	.75	1.52	3.08	6.18	12.61	.81	1.60	3.44	7.54	16.12	.86	−.06	−.05
October	.88	1.63	3.15	6.23	12.41	.88	1.66	3.31	7.05	15.17	.88	.00	.00
November	1.01	1.89	3.52	6.07	12.90	.93	1.74	3.34	6.78	14.33	.91	+.08	+.02
December	.94	1.96	3.84	7.36	14.03	.92	1.80	3.46	6.77	13.82	.96	+.02	−.04
1920													
January	.83	1.77	3.72	7.56	14.92	.92	1.85	3.59	6.93	13.71	1.02	−.09	−.10
February	.86	1.69	3.46	7.18	14.94	1.05	1.97	3.77	7.23	14.00	1.07	−.19	−.02
March	1.47	2.33	4.02	7.48	14.60	1.26	2.18	4.03	7.62	14.56	1.11	+.21	+.15
April	1.48	2.95	5.28	9.30	16.78	1.31	2.32	4.33	8.10	15.23	1.12	+.17	+.19
May	1.09	2.57	5.52	10.80	20.10	1.17	2.43	4.61	8.64	16.26	1.11	−.08	+.06
June	.95	2.04	4.61	10.13	20.98	1.02	2.33	4.69	9.02	17.12	1.06	−.07	−.04
July	.97	1.92	3.96	8.57	18.70	.95	2.12	4.55	9.16	17.80	1.02	+.02	−.07
August	.90	1.87	3.79	7.75	16.32	.92	1.94	4.27	8.96	17.98	.99	−.02	−.07
September	.90	1.80	3.67	7.46	15.21	.92	1.87	3.99	8.54	17.70	.98	−.02	−.06
October	.91	1.81	3.62	7.29	14.75	.96	1.88	3.82	8.09	17.05	.99	−.05	−.03
November	1.07	1.98	3.80	7.42	14.71	1.08	1.95	3.82	7.81	16.35	1.08	+.04	.00
December	1.12	2.19	4.17	7.97	15.39	1.07	2.03	3.91	7.73	15.82	1.07	+.05	.00

THE FLOODS OF MARCH, 1928, IN THE SACRAMENTO VALLEY

By N. R. TAYLOR

The first intimation of high water in the sections involved were the general and fairly heavy rains of March 23, which were coextensive with those in the mountain and foothill sections of the Sierra Nevada and in the Sacramento Canyon from Redding to Sisson, and thence northward to the southern slope of the Siskiyous. At no time during the high waters was there any snow on the flanks of the mountains, and that on the ground was confined to the extreme altitudes, where there was much less than usually has accumulated at this season of the year. For these reasons there was but little apprehension of danger.

On the morning of March 24 the rains were still in progress, with heavy amounts throughout the mountains, the Sacramento Canyon, and the upper regions of the Mokelumne-Cosumnes Rivers, and it seemed evident that they would continue for an indefinite period and probably would result in moderately high stages in many of the rivers in the drainage basin of the Sacramento River.

At this time there were unusually large numbers of cattle and sheep ranging much farther away from the river than is usual at this particular season of the year. Warnings were sent to all interested that the lowlands adjacent to the Sacramento River probably would overflow during the next day or two, and of all the advices distributed during the prevalence of the high waters none was more valuable nor timely, as, with one exception, they were immediately heeded.

Later during the day of March 24 special messages received indicated exceptionally heavy rains throughout the American River watershed, especially in the high regions drained by the forks of this stream, which were rapidly rising.

Acting on this information the California State Highway Commission was notified that the subways leading out of Sacramento to the north would be in danger of overflow. The city officials of Sacramento also were informed of the prevalence of the heavy rains in the American River drainage basin.

By the morning of the 25th the American River at Folsom had reached a stage in excess of 22 feet and was rising rapidly with all forks of this stream running at high stages. Rapidly rising rivers also were reported from the upper reaches of the Feather-Yuba and from the high stretches of Alpine County which drain into the Mokelumne and Cosumnes Rivers, making it advisable to issue warnings to Bensons Ferry, Lodi, and New Hope Landing in the lower reaches of the two streams referred to.

Early during the morning of the 25th the subways were rapidly becoming covered with water and warnings were immediately sent to North Sacramento, a settlement across the American from Sacramento City, that all but the high sections in that settlement would be flooded by or before night. Later during this day the warnings were made urgent, and many whose homes were in the lower spots began moving their furniture to places of safety. At 1 p. m. of the 25th, the unprecedentedly high stage of 40 feet was reported from the suspension bridge at the junction of the middle and north forks of the American River near the town of East Auburn, and at about 4 p. m. of this date the American River at Folsom crested at 26.8 feet equaling the high water at that point of March, 1907, and exceeding by over 2 feet that of the floods of 1909.

By noon of the 25th the back water from Sacramento began spreading over some of the lowland in North Sacramento and by night that settlement was practically isolated, and the water was overflowing from the American into the hop lands and vineyards in the vicinity of Mills Station. About this time the H Street Bridge was completely surrounded by water and there was no outlet by land on the north side of Sacramento.

At about 1 p. m. of the 25th 20 gates of the Sacramento by-pass were opened and that night the remaining gates, except one which became jammed, were opened, and the next morning the refractory gate was dynamited, making 48 gates in all through which the water was flowing into Yolo Basin. As soon as the first group of gates was opened, warnings were given the Courtland operator for distribution to all patrons in the basin, and another warning was sent when the remaining gates were opened, with the additional information to the effect that Fremont Weir, which opens into Yolo Basin near the mouth of the Feather River, soon would be discharging and that Putah Creek would add considerable water to that already flowing down the trough of this sink.

Late during the night of the 25th the situation in North Sacramento was becoming serious, and in many cases the water had reached the first floors of houses, from which families were being rescued by rowboats, launches, and rafts.

All during the night of the 25th there was a panic in the rather populous settlement across the river, and there were many pitiful calls to the Weather Bureau from houses where the telephone lines continued intact, and from persons in the city of Sacramento itself, who had interests in the suburban town. Women with babies in arms, old people and invalids, some practically helpless, all were frantic as they viewed the swirling waters hurrying past their houses with no assurance that foundations would hold. Of course, everything was being done that could be done, and the work of rescue proceeded with surprising speed when the general conditions were considered. One old man was swept away by the current and drowned while trying to get his family out and a large number of people had narrow escapes. A number of Japanese were marooned in a particularly low spot, and their cries, in almost unintelligible English, added pathos to the already touching situation. "Would the honorable weather man please stop the waters from covering us up," was caught among the plaintive jargon that drifted tearfully in over the phone, and, "For God's sake, open the floodgates and let the water drain away," came in oft-repeated refrain.

At 3 a. m. of the 26th the river at Sacramento crested at 29.5 feet, which is just 0.1 foot below the highest stage ever recorded since the great floods of 1862. On this date the American at Folsom had fallen considerably from its crest stage of the preceding date, but the Feather-Yuba and Bear Rivers were moderately high and rising with heavy rains still in progress, especially in the north fork of the Yuba, in the vicinity of Colgate, where torrential rains were reported. At this point the river already had crested at 7 a. m. of the 25th at the high stage of 20 feet, but it again rose rapidly after the observation of the 26th and by 10 p. m. of this date a stage of

21 feet was reached. During the passage of this last flood wave the river gauge, which was anchored to a rock in midstream was washed away, and it is thought that the rock itself was moved. Through the courtesy of the Pacific Gas & Electric Co., numerous reports were telephoned, making it possible to keep closely in touch with the passage of the up-Yuba high water.

On the 26th general flood warnings of dangerously high water with occasional flood stages were broadcast by every available method to all sections on the Sacramento River and its tributaries, except the American and Pit Rivers. Flood warnings already had been sent to the lower Mokelumne and Cosumnes Rivers which at this time were rapidly rising. On this date there was no improvement in the town of North Sacramento, where all low parts were flooded, notwithstanding the fact that immense amounts of water were flowing through Fremont Weir and the Sacramento by-pass. To all inquirers from the Feather-Yuba sections where the waters still were rising, it was stated that the crest of the upper regions of these streams would not reach the lower Feather River before the 27th, and it was advised that all levees be closely watched for leaks and gopher holes.

On the morning of March 26th all the lowlands in North Sacramento were flooded and every outlet leading out of the city of Sacramento to the north was blocked by water. The highest water in the afflicted town was reached at about 2 a. m. of this date, after which it began very slowly to recede. Assurances were given that the worst was about over, although the work of rescue was still going on and the warnings given the city during the previous day to patrol all levees were repeated. It was stated that although the crest of the American River flood was passing downstream, there was still sufficient water in the Feather and the intermediate reaches of the Sacramento to keep the river between Knights Landing and the mouth of the American at a high stage for several days.

On the 26th the waters of Fremont Weir, those of the Sacramento by-pass, and the discharge of Putah Creek had accumulated in the lower portion of Yolo Basin, and by night of this date Liberty and Prospect Islands, the upper portion of the Hasting tract, and a number of smaller holdings were under water. All these lands were planted to sugar beets, asparagus, and grain, causing the heaviest losses sustained in any of the flooded areas of the Sacramento Valley. The levees which protected "Permanent" Liberty held, as did those of the Egbert tract, but there was considerable seepage from all levees which skirted Cache Slough from which no small damage resulted. Other than that mentioned there was no further damage in the basin, and there was none at all in the lower reaches of the Sacramento, notwithstanding the fact that the waters remained dangerously high from Courtland to Isleton for several days.

In the meanwhile, on March 26th, heavy rains still were falling in the extreme upper watershed of the Sacramento River from Kennett as far up as Sisson, which seemed to justify supplementary advices to the observer at Red Bluff to warn all interests that the flood stage would be reached at that point during the night.

Early during the morning of the 27th the river at Kennett crested at 23 feet, and at 10 a. m. of this date a stage of 26.9 feet was reached at Red Bluff, but shortly after this hour a general fall was in progress from Tehama to the extreme upper reaches of the river. However, at this time the heavy rains which occurred in the forks of the Feather during the preceding date were being reflected in the river in the vicinity of Oroville, which was rapidly rising, reaching its crest, 27 feet, just before midnight of the 26th. The Yuba River at Marysville already had responded to the flood wave of its upper forks, reaching a stage at that point of 24 feet at 5 a. m. of the 27th, or 0.1 foot above the previous high-water record of January 16, 1909.

During the 27th the lower Feather was dangerously high as this reach of the river began to respond to the upper flood wave of that stream before that of the Yuba had passed, although there was some relief afforded by the breaking of levees in the vicinity of Alicia, causing the flooding of quite an extensive area planted to onions and sugar beets, the water spreading to and covering the town of Arboga. Other slight relief resulted in the escape of the excess waters at Hamilton Bend, which flowed westward north of Marysville Buttes between Gridley and Biggs and thence down Butte Slough to Butte Basin, where they were taken care of. A like condition occurred during the floods of 1907 and 1909, but during the last named flood the waters flowing over Hamilton Bend found their way to the town of Meridian, causing a break in the levees, which protected district 108 at Moon's Bend and flooded a large area in Colusa Basin.

The Feather River at Nicolaus, near the junction of the Feather and Bear Rivers, about 7 a. m., March 28, reached a crest of 23.2 feet, 0.2 foot above the previous high-water mark of January 1, 1914, and the same amount above the crest forecast for that place. During the night of the 27th the levees that protected the lands below this town began sloughing, a condition which continued during the 28th, necessitating the employment of about 100 men to keep them in repair.

Some of the warnings distributed by telephone during the 27th stated that the upper Sacramento flood-wave was hurrying downstream, and advised that all levees between Stony Creek and the mouth of the Feather should be closely watched during the next 24 hours. Inquiries from the manager of the Monroeville Orchard Co. were answered with the information that the probability was that some of the lands in the vicinity of Hamilton City would overflow before the passage of the high water. The wave reached Hamilton City during the night of the 28th, when the current was so strong as to tear from its support the river gauge on Gianela Bridge without leaving a vestige behind.

The Mokelumne at Bensons Ferry reached flood stage early during the morning of the 27th and at about 2.30 p. m. of this date crested at 13.8 feet, 1.8 feet above flood stage, causing the flooding of a large area of land in the vicinity of Lodi and New Hope Landing.

On the 28th the Sacramento in its reaches adjacent to the American still maintained high stages, but the tendency was to slowly fall. It still was high from Walnut Grove to the mouth of Cache Slough, which was discharging heavily, and it was estimated that the combined flood waves of the American and Feather Rivers were somewhere between those two points.

At 7 a. m. a stage of 19.2 feet was reported from Knights Landing, and although the crest of the up-river wave was still above Colusa, the river at Knights remained stationary at the stage quoted until the evening of the 30th, when it began to fall slowly. This was an unusual condition for the place in question, as crest stages at Knights Landing have always followed those of Colusa from 12 to 16 hours later. The cause, no doubt, was due to the flattening of the wave as it proceeded downstream below Colusa, and also because of the dis-

charge of Fremont Weir, which was handling much of the water which came out of the Feather and permitted of a more rapid run-off of the Sacramento below Knights Landing. In any event a stage of 20 feet was forecast for the place in question which, even at this time, seems quite a logical prediction when the conditions that occurred above are considered.

On the morning of the 29th the river at Colusa was still rising slowly, cresting at 25.7 feet at about 2.30 p. m., or just 0.3 foot above the stage forecast. On this date the water had receded from the town of North Sacramento, where a condition of tragic destruction was disclosed. The first floors of a large number of houses were covered with muck and in many cases the foundations of the houses themselves were undermined. Innumerable pieces of furniture either were totally destroyed or else damaged beyond repair. According to a conservative estimate made by the officials of the Red Cross Society, who nobly responded to the calls of the needy, the total damage to the afflicted town exceeded $100,000.

On the 29th all streams had fallen to safe stages, except that the Sacramento below Walnut Grove was still high, but the widening of the river in its lower reaches permitted of a rapid run-off and prevented any overflow below the mouth of Cache Slough. Considerable water was still flowing through Fremont Weir into Yolo Basin, the lower portions of which continued under water.

During the 29th the city officials of Sacramento and representatives of the United States Corps of Army engineers began closing the gates of the Sacramento by-pass in order that the scouring effects of the high water below the mouth of the American might be secured.

On the morning of the 30th the floods were practically over, although the Sacramento from the mouth of the American to Cache Slough was still maintaining moderately high stages, and the lower portion of Yolo Basin remained under water, a condition which prevailed until several days later. The city of Sacramento still was below the level of the river, but all levees which protected the city were holding, as they did throughout the high water, and at no time was the city in imminent danger of overflow.

The floods of March, 1928, in the Sacramento River and in some of the Feather-Yuba sections, did not equal those in the Sacramento drainage basin of March, 1907, and January, 1909, and those in the Mokelumne-Cosumnes were far less serious than the San Joaquin Valley floods of 1911. Compared with the floods named the damage wrought was at least one-third less, but the American, both in its main course and that of its forks, rose higher than in any flood since the high water of 1862, the damage from which was reflected in the heavy losses in North Sacramento and some local damage to the lands adjacent to the river in the vicinity of Mills Station, as well as to the Fair Oaks Bridge, which was damaged. There was, however, much excitement, especially in the vicinity of Sacramento, owing to irresponsible statements that there would be a repetition of the great floods of 1862.

The floods in question would have been far more destructive had there been as much snow in the intermediate altitudes of the mountains as had accumulated during the floods of 1907 and 1909, but, as already stated, the snow pack was confined to the extreme altitudes, where it was much below the normal, and although some rain fell during the period of high water as far up as the summit of the Sierras, there was practically no run-off from snow water at any time during the floods. In fact, it was the first destructive flood which was ever known to occur in the central valleys of California to which snow water did not largely contribute its quota.

While an unusual effort was made to secure the tabulated data of losses, etc., included herein, it is realized that many of the items treated are incomplete. However, they are as nearly correct as it is possible to make them.

FLOODS OF MARCH, 1928

Estimated money value of losses sustained during the floods:

Buildings and furniture [1]	$107, 000
Crops [2]	220, 000
County roads (erosion)	5, 000
County bridges	65, 000
Damage to lands (washouts)	20, 000
Levees carried away	127, 000
Railroads	110, 000
Stock	2, 500
Due to suspension of business	35, 000
Labor and dredges keeping levees from breaking	20, 000
Miscellaneous losses	25, 000
Total	736, 500

Value of property estimated saved by reason of warnings:

Stock	$25, 000
Levees	90, 000
Farming implements, furniture, etc	75, 000
Miscellaneous	10, 000
	200, 000

There no doubt were some lives saved in Yolo Basin, as it is understood that there were some narrow escapes in getting out of the way of the water, which flowed into this sink from the combined output of Putah Creek, Fremont Weir, and the Sacramento By-pass.

HIGH WATER OF MARCH, 1928

The following table gives the precipitation for the month of March, 1928, at river stations, also the highest river stages and dates, and departures from flood stages.

Stations	River	Monthly precipitation	Highest stage	Date	Departure from flood stage
			Ft.		*Ft.*
Bensons Ferry	Mokelumne	3. 66	13. 8	28th	+1.8
Colgate	Yuba	13. 87	23. 4	27th	+0.4
Colusa	Sacramento	3. 34	25. 7	29th	−3.1
Folsom	American	5. 97	26. 8	25th	----------
Electra	Mokelumne	10. 20	11. 5	25th	−0.5
Hamilton	Sacramento	3. 43	22. 0	28th	0.0
Kennett	do	10. 65	23. 0	27th	−2.0
LaGrange	Tuolumne	3. 61	8. 0	26th	0.0
Marysville	Feather	4. 36	24. 0	27th	−4.0
Nicolaus	do	4. 34	23. 2	28th	−1.8
Oroville	do	6. 65	27. 0	27th	+2.0
Red Bluff	Sacramento	3. 78	26. 9	27th	+3.9
Sacramento	do	3. 30	29. 5	26th	+0.5
Knights Landing	do	3. 37	19. 2	28th to 30th	+1.2
Lathrop	San Joaquin	2. 32	16. 4	29th	−0.6

RAINFALL FROM MARCH 23 TO 27, INCLUSIVE (INCHES)

Auburn	8. 30	Grass Valley	13. 48
Bensons Ferry	2. 70	Inskip	14. 78
Blue Canyon	14. 00	Knights Landing	2. 71
Bowmans Dam	17. 18	Kennett	5. 91
Camptonville	14. 49	LaGrange	2. 56
Chester	5. 92	Lake Spaulding	18. 14
Colfax	10. 40	Lathrop	2. 00
Colgate	10. 12	Los Plumas	9. 76
Colusa	2. 64	Nicolaus	3. 28
Deer Creek	19. 14	North Bloomfield	12. 28
De Sabla	11. 65	Norden	10. 46
Dobbins	8. 73	Quincy	9. 05
Downieville	14. 61	Red Bluff	2. 99
Electra	8. 17	Sacramento	1. 89
Folsom	4. 47	West Branch	15. 90
Fordyce Dam	18. 30		

[1] Either totally destroyed furniture or cost of repair.
[2] Includes those lost and prospective crops.

WEATHER AND PROBABILITY OF OUTBREAKS OF THE PALE WESTERN CUTWORM IN MONTANA AND NEAR-BY STATES[1]

By WILLIAM C. COOK[2]

[Assistant Entomologist, Montana Agricultural Experiment Station, Bozeman, Mont.]

It has been shown by Seamans (1) and by the writer (2) that variations in the population of the pale western cutworm (*Porosagrotis orthogonia* Morr.) may be forecast with a high degree of reliability from the rainfall in the spring of the preceding year. Seamans showed that if there were less than 10 days in May and June upon which 0.25 inch of rainfall was recorded, *orthogonia* would increase in the following year, while if there were more than 10 "wet" days, *orthogonia* would decrease. I have shown, similarly, that if the total rainfall in May, June, and July was less than 4 inches, the population would increase, while if this total was more than 5 inches, the population would decrease.

These two methods of predicting changes in abundance may easily be harmonized. It is well known that there is a definite relation between total rainfall and the frequency of various amounts in single showers. Cole (3) has shown that in the Judith Basin region of Montana less than 25 per cent of the total rainfall from April 1 to September 1 falls in showers of less than 0.20 inch. This relation should hold approximately for May, June, and July. Since Seamans has used only the rainfall for May and June, in which the heaviest rain falls, 3 inches may be taken as the critical total for these two months. Assuming 25 per cent, or 0.75 inch, to fall in light showers, this would leave 2.25 inches—sufficient for eight or nine showers of 0.25 inch each. It seems probable that a careful analysis of long records in this region would bring the two forecasting methods into still closer correspondence.

Statistical studies of over 60 weather records for an outbreak of *P. orthogonia* in Montana from 1918 to 1922 have shown biserial correlations between rainfall and presence of damage as follows:

Period	Correlation coefficient (r)
May of preceding year	−0.471 ± 0.105
June of preceding year	−.572 ± .092
July of preceding year	−.675 ± .053
May and June, total	−.730 ± .050
May, June, and July, total	−.766 ± .045

A correlation of −0.766 indicates a relation, as measured by $\sqrt{1-r^2}$, of 0.643, showing well over half the possible causes accounted for. This relation to rainfall may be regarded as vital, and a calculation of the probability of outbreaks upon this basis should give a maximum value as other neglected factors would probably operate to reduce rather than increase the number of outbreaks.

In the paper previously referred to (2), I have shown that the critical factor is really soil moisture, which is a function of temperature as well as of rainfall. Within the region covered by this study, however, temperatures are very uniform at this time of the year, and would cause very small changes in the critical rainfall of 4 inches.

The problem is thus resolved into a study of the probability that the total rainfall from May 1 to August 1 will be less than 4 inches. This probability measures the adaptability of the climate for continued habitation by *P. orthogonia*, but will not measure the probability of a serious outbreak. Careful field and laboratory studies have shown that even under the most favorable conditions, this species is rarely able to more than treble its population from one year to another. Field studies have shown that the normal population, in cutworm areas, when there is no outbreak, is less than one larva per square yard, while it requires at least six per square yard to produce severe damage. This would indicate that at least two favorable years are necessary to produce an outbreak, which is substantiated by the fact that every severe outbreak studied has been preceded by at least two favorable years.

Thus, as a second necessary factor, the probability of two successive dry years is needed. For these analyses long continuous rainfall records are necessary. Within the Montana area occupied by *P. orthogonia* (4), six such records have been selected (Helena, Havre, Crow Agency, Miles City, Glendive, and Poplar). A seventh long record from Bozeman, just outside the region occupied by *orthogonia*, has been added for comparison. The severe outbreak of *orthogonia* in Montana was accompanied by a widespread but less severe outbreak in western North Dakota, indicating a decrease in severity with increase in normal rainfall. Williston and Bismarck, N. Dak., and Moorhead, Minn., have been added to show the influence of this factor upon the probability of outbreaks. Outbreaks of *orthogonia* have occurred in northeastern Colorado; and Cheyenne, Wyo., and Fort Collins, Colo., represent this area. Unfortunately no long records exist in the small areas covered by very recent outbreaks in northeastern New Mexico and extreme western Oklahoma.

THE PROBABILITY OF 4 INCHES RAINFALL OR LESS DURING MAY, JUNE, AND JULY AT THE SELECTED STATIONS

As is generally known, rainfall values in arid regions form a skew distribution, in which the mode is usually less than the mean. This is the case in this study, and it is perfectly useless to apply a normal curve. A simple counting of the values below 4 inches would be more accurate. It would be possible to fit a form of Pearson's generalized frequency curve to each of them, but the process is very laborious. Tolley (5) has published an alternative family of frequency curves, especially adapted for this type of work, and has tabulated the probability of deviations in terms of the standard deviation for selected values of skewness. His measure of skewness, K, is the ratio $\mu 3/\sigma^3$, so that all necessary constants are derived from the first three moments. His curves have been fitted to the rainfall distributions for the selected stations. These distributions, together with the various constants, are given in Table 1, and the histograms are plotted in Figure 1.

---

[1] Contribution from the entomology department, Montana Agricultural Experiment Station.

[2] The writer wishes to acknowledge the advice and assistance of Prof. W. D. Tallman, head of the mathematics department, Montana State College, in this and other similar studies.

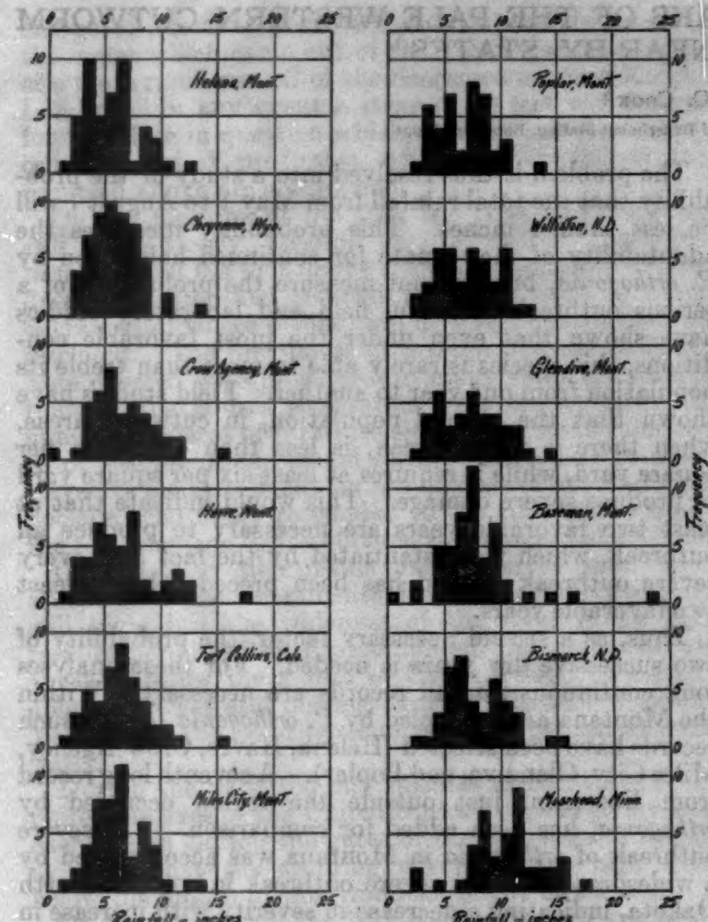

FIG. 1.—Frequency of various amounts of rainfall at the 12 selected stations. (See Table 1)

TABLE 1.—*Frequency distributions and statistical constants for May–July rainfall at 12 selected stations*

Total rainfall, inches	Helena, Mont.	Cheyenne, Wyo.	Crow Agency, Mont.	Havre, Mont.	Fort Collins, Colo.	Miles City, Mont.
0.00–0.99			1			
1.00–1.99	1			1	1	1
2.00–2.99	5	4	1	4	3	2
3.00–3.99	10	7	5	4	5	4
4.00–4.99	5	9	6	7	4	8
5.00–5.99	7	10	8	6	7	8
6.00–6.99	10	9	4	5	9	11
7.00–7.99	1	8	5	8	6	3
8.00–8.99	4	5	4	2	4	6
9.00–9.99	3		3	1	2	4
10.00–10.99	1	2	2	2	2	1
11.00–11.99			2	3	1	
12.00–12.99	1			2		1
13.00–13.99		1				1
14.00–14.99						
15.00–15.99			1		1	
16.00–16.99						
17.00–17.99				[1]1		
18.00–18.99						
19.00–19.99						
20.00–20.99						
21.00–21.99						
22.00–22.99						
23.00–23.99						
Record, year's	48	55	42	45	45	50
Mean (M)	5.563	5.918	6.595	6.433	6.400	6.400
Standard deviation (σ)	2.332	2.169	2.912	2.825	2.644	2.418
Coefficient of variation	41.9	36.6	44.2	45.3	41.4	37.8
Third moment (μ_3)	+6.778	+8.410	+18.362	+11.279	+16.516	+8.760
K	+0.535	+0.824	+0.744	+0.500	+0.893	+0.630
Probability of 4 inches or less (per cent)	26.78	19.39	19.37	19.14	18.89	16.08
Average interval, years	3.74	5.15	5.15	5.23	5.29	6.21

[1] These values were omitted in making the calculations.

TABLE 1.—*Frequency distributions and statistical constants for May–July rainfall at 12 selected stations*—Continued

Total rainfall, inches	Poplar, Mont.	Williston, N. Dak.	Glendive, Mont.	Bozeman, Mont.	Bismarck, N. Dak.	Moorhead, Minn.
0.00–0.99				1		
1.00–1.99						
2.00–2.99	1	2	1	2	1	2
3.00–3.99	6	3	4		1	
4.00–4.99	4	6	6	5	3	1
5.00–5.99	7	6	3	5	7	
6.00–6.99	2	3	4	8	8	1
7.00–7.99	8	6	6	12	4	4
8.00–8.99	7	5	4	4	3	7
9.00–9.99	2	3	4	7	6	3
10.00–10.99	3	6	3	2	4	5
11.00–11.99		1	3		3	9
12.00–12.99		1	1	1		2
13.00–13.99	1					2
14.00–14.99			1	1	1	2
15.00–15.99					1	3
16.00–16.99				1		
17.00–17.99						1
18.00–18.99						
19.00–19.99						
20.00–20.99						
21.00–21.99						
22.00–22.99						
23.00–23.99				[1]1		
Record, year's	41	42	40	50	42	42
Mean (M)	6.744	7.095	7.375	7.398	7.833	10.357
Standard deviation (σ)	2.410	2.583	2.846	2.757	2.759	3.213
Coefficient of variation	35.7	36.5	38.5	37.3	35.2	31.1
Third moment (μ_3)	+5.138	+1.733	+8.221	+13.271	+13.026	−8.532
K	+0.367	+0.100	+0.357	+0.633	+0.630	−0.257
Probability of 4 inches or less (per cent)	12.33	11.37	11.23	9.94	6.75	3.01
Average interval, years	8.11	8.80	8.90	10.10	14.81	3.32

[1] These values were omitted in making the calculations.

From a climatological standpoint, the table calls for a few comments. The coefficient of variation ($100\sigma/M$) shows a fairly regular decrease from west to east, as may be seen by comparing Havre (45.3), Miles City (37.8), Williston (36.5), Bismarck (35.2), and Moorhead (31.1). This is roughly parallel to the increase in total rainfall.

The skewness of the distribution is positive in every case except Moorhead, and negative skewness is obvious in the histogram for that station. Williston has a freakish distribution, with little skewness, showing nearly equal frequencies in the central classes. Poplar and Glendive, the nearest Montana stations, also show this property in a less pronounced form. It is difficult to predict just what sort of a curve would be obtained from longer records. These stations are directly in the path of the Alberta cyclones in summer, and this may possibly be a factor in producing the irregular curves. Elsewhere in the table, the values of K for the Northern States fall near $+0.600$, and in Colorado near $+0.800$.

The values of the probability (P) of 4 inches rainfall or less, obtained by interpolation from Tolley's table (5) p. 640–641) show a wide variation. This probability gives a clue to the conditions which determine the distribution of this species. *P. orthogonia* is known to maintain a small population near Miles City ($P=16.08$) and does not maintain itself near Bozeman ($P=9.94$). This would indicate that a limiting value would be slightly above $P=10$. The species has migrated, in favorable years, into the region near Bismarck ($P=6.75$), but has never been reported near Moorhead ($P=3.01$). This indicates that outbreaks caused by migrating moths would probably occur within lines indicating values of P between 5 and 10.

Another way of conveying the same information is by means of the reciprocal of P, or the average interval

between favorable years. The average intervals are given in the lowest line of Table 1. Translating the above paragraph into terms of average interval, it may be stated that *P. orthogonia* can maintain itself at all times only in regions where at least 1 year in 10 is favorable for an increase. It can produce sporadic outbreaks, by migration, in regions where more than 1 year in 20 is favorable. This latter interval marks the extreme limit of the economic distribution. Only isolated specimens will be found elsewhere.

THE PROBABILITY OF TWO SUCCESSIVE FAVORABLE YEARS

According to the laws of chance, if the chance of a single favorable year is P, then that of two successive favorable years is P^2, *assuming a random (normal) distribution of rainfall values.* A large amount of work has appeared recently which attempts to discern cycles in the values of weather elements. It is not within the scope of this paper to discuss any possible cycles, but a mere inspection of any rainfall record from the Great Plains area will show a decided tendency for like years to succeed each other. There is a very simple method of evaluating this tendency, while avoiding any implication of cyclic action. If there is no tendency for like years to succeed each other, the differences between successive years, taken *without regard to sign*, should form a normal distribution. If such a tendency be present, there should be an accumulation of small differences, producing a curve of positive skewness. From this difference curve, following the method of Tolley, the probability of any desired degree of similarity may be calculated. Since I have shown (2) that the critical range is 4 to 5 inches, it is sufficient to determine the probability of a deviation of 1 inch or less. Distributions of the interannual differences for the selected stations, with their constants, and the probability of a deviation of 1 inch or less are given in Table 2.

TABLE 2.—*Frequency distribution and statistical constants for interannual differences in May-July rainfall*

Difference in inches	Helena, Mont.	Cheyenne, Wyo.	Crow Agency, Mont.	Havre, Mont.	Fort Collins, Colo.	Miles City, Mont.
0.00-0.49	8	3	5	7	2	5
0.50-0.99	6	7	4	6	2	8
1.00-1.49	4	10		3	4	5
1.50-1.99	6	7	4	5	10	3
2.00-2.49	3	5	5	1	3	4
2.50-2.99	5	12	4	2	1	4
3.00-3.49	2	5	1	3	4	6
3.50-3.99	2		3	1	2	6
4.00-4.49	2	1	3	4	3	2
4.50-4.99	6				1	2
5.00-5.49			2	4	3	
5.50-5.99	1	2	2	1	2	
6.00-6.49	1	1	1	1		1
6.50-6.99	1		1		1	1
7.00-7.49				1		1
7.50-7.99		1	1	1	1	1
8.00-8.49				1		
8.50-8.99				1		
9.00-9.49						
9.50-9.99						
10.00-10.49						
10.50-10.99			1	1	1	
11.00-11.49						
11.50-11.99			1			
12.00-12.49					1	
12.50-12.99						
Year's	40	54	38	43	41	49
Mean difference	2.358	2.242	3.289	3.128	3.329	2.587
Standard deviation (σ)	1.792	1.495	2.652	2.670	2.568	1.861
Coefficient of variation	75.0	66.7	80.6	85.4	77.2	71.9
Third moment (μ_3)	+3.511	+5.102	+23.555	+16.798	+27.401	+5.588
K	+0.610	+1.519	+1.264	+0.883	+1.618	+0.680
Probability of a difference of 1 inch or less	23.62	22.56	23.20	22.83	17.69	20.49

TABLE 2.—*Frequency distribution and statistical constants for interannual differences in May-July rainfall*—Continued

Difference in inches	Poplar, Mont.	Williston, N. Dak.	Glendive, Mont.	Bozeman, Mont.	Bismarck, N. Dak.	Moorhead, Minn.
0.00-0.49	2	6	1	4	3	2
0.50-0.99	3	1	4	7	7	2
1.00-1.49	3	5	2	2	4	4
1.50-1.99	3	2	5	4	1	5
2.00-2.49	4	3	3	7	2	1
2.50-2.99	3	6	2	6	3	3
3.00-3.49	3	1	3	1	1	4
3.50-3.99	1	5	4	1	7	1
4.00-4.49	2	2	2	2	5	4
4.50-4.99	4	3	2	1	3	3
5.00-5.49	3	1	1	1	1	2
5.50-5.99	1	1	1	2	1	
6.00-6.49			1			2
6.50-6.99	1		1		1	2
7.00-7.49	2	2		1	1	
7.50-7.99		1				1
8.00-8.49			1			3
8.50-8.99			1	1	1	1
9.00-9.49			1			
9.50-9.99			1			
10.00-10.49				1		
10.50-10.99						1
11.00-11.49						
11.50-11.99				1		
12.00-12.49						
12.50-12.99						
Year's	35	41	38	44	41	41
Mean difference	3.243	2.970	3.421	3.023	2.988	3.988
Standard deviation (σ)	1.954	1.973	2.511	2.609	2.017	2.608
Coefficient of variation	60.3	66.5	73.4	86.3	72.6	65.4
Third moment (μ_3)	+3.115	+4.033	+1.916	+26.536	+4.685	+10.639
K	+0.417	+0.525	+0.968	+1.496	+0.565	+0.600
Probability of a difference of 1 inch or less	12.05	15.87	16.36	24.74	16.21	11.84

With the exception of Bismarck and Miles City, the stations show a markedly more skew distribution of differences than that for the original records. In three cases extrapolation was necessary, as Tolley's table extends only to K = +1.4. In the cases of Helena and Havre, the fit of Tolley's curve was forced, as the highest frequencies are concentrated in the first two classes, showing almost a hyperbolic relationship. As the records are comparatively short, there seemed to be no object in attempting to get a better fit with some other curve. These variations, however, did have a decided effect upon the relation of actual to calculated probability. Bozeman has a very skewed curve and a wide variability.

The values of P at the bottom of the table indicate only the probability of two like years, regardless of the absolute value. They must be considered in connection with the values of P for the probability of a single year with less than 4 inches rainfall. Both values of P, with the compound probability (calculated from P_1^2 and also from $P_1 \times P_2$), the average interval between outbreaks, and the actual and computed numbers of pairs of dry years in each record, are given in Table 3.

TABLE 3.—*The probability of cutworm outbreaks*

Column	1	2	3	4	5	6	7	8
Station	Length of record, years	Chance of less than 4 inches rainfall (P_1)	Chance of less than 1 inch deviation (P_2)	Chance of 2 successive years, calculated from— $(P_1)^2$	Chance of 2 successive years, calculated from— $(P_1) \times (P_2)$	Average interval, years	Pairs of years with less than 4 inches rainfall each— Expected	Pairs of years with less than 4 inches rainfall each— Found
		%	%	%				
Helena, Mont.	48	26.78	23.62	7.2	6.3	16	3.02	6
Cheyenne, Wyo.	55	19.39	22.56	3.8	4.4	23	2.42	3
Crow Agency, Mont.	42	19.37	23.20	3.7	4.5	22	1.89	1
Havre, Mont.	45	19.14	22.83	3.7	4.4	23	1.98	2
Fort Collins, Colo.	45	18.89	17.69	3.6	3.3	30	1.49	1
Miles City, Mont.	50	16.08	20.49	2.6	3.3	30	1.66	0
Poplar, Mont.	41	12.33	12.05	1.5	1.5	67	0.61	1
Williston, N. Dak.	42	11.37	15.87	1.3	1.8	55	0.76	2
Glendive, Mont.	40	11.23	16.36	1.2	1.8	55	0.72	1
Bozeman, Mont.	40	9.94	24.74	0.9	2.5	40	1.22	0
Bismarck, N. Dak.	42	6.75	16.21	0.5	1.1	91	0.46	0
Moorhead, Minn.	42	3.01	11.84	0.1	0.4	250	0.17	0

As all of these calculations are based upon relatively short records, it did not seem wise to give a false impression of accuracy by carrying the final probability values to many decimals, and the average intervals are given to the nearest whole year.

Column 6 of this table shows that severe outbreaks of *P. orthogonia* may be expected about once in 20 years in central Montana and Wyoming, about once in 30 years in eastern Montana and Colorado, and about once in 50 years in North Dakota. The interval of 250 years at Moorhead places this station definitely outside the economic distribution of this insect. It is, of course, possible that one extremely favorable year following one with a rainfall btween 4 and 5 inches may cause a local outbreak of moderate severity, and such local outbreaks may be expected somewhat more frequently. There are indications, not climatic in character, that a small district in southern Alberta and extreme north-central Montana may suffer more frequent outbreaks than any other region studied, but no long rainfall records are available for a climatic study.

The comparison of actual and expected pairs of dry years shows a fairly close fit of theory to observation. The wide deviation in the case of Helena is explained above, while in the case of Crow Agency there are several gaps in the record which might have included one or more dry years.

CONCLUSIONS

This study has shown that there is a close connection between the chances of a single favorable year and the ability of *Porosagrotis orthogonia* to maintain itself at a place. At least 1 year in 10 must be favorable to increase or the insect will disappear. Outbreaks brought on by migrating moths are confined to regions where at least 1 year in 20 is favorable.

There is a decided tendency for like years to follow in succession, and this tendency was evaluated, without any implication of periodicity, by forming a distribution curve of interannual differences, neglecting signs. In all cases a decidedly skewed distribution was obtained from which the probability of a deviation of 1 inch or less between successive years was calculated.

Severe attacks of the pale western cutworm may be expected only at long intervals in most parts of its range. In the dry mountain foothills near Helena such outbreaks will be about 16 years apart, on the central plains of Montana and in Wyoming it may occur once in 20 to 25 years, and in eastern Montana and Colorado the average interval between outbreaks is about 30 years. In other parts of its range in the United States it will probably be more rarely injurious. Light outbreaks may be expected somewhat more frequently.

LITERATURE CITED

1. Seamans, H. L. 1923. Forecasting outbreaks of the pale western cutworm in Alberta. *Can. ent.* 55: 51–53.
2. Cook, W. C. 1926. Some weather relations of the pale western cutworm (*Porosagrotis orthogonia* Morr.). A preliminary study. *Ecology* 7: 37–47.
3. Cole, J. S. 1922. The daily quantities in which summer precipitation is received. Mon. weather rev. 50: 572–575.
4. Cook, W. C. 1924. The distribution of the pale western cutworm, *Porosagrotis orthogonia* Morr.: A study in physical ecology. *Ecology* 5: 60–69.
5. Tolley, H. R. 1916. Frequency curves of climatic phenomena. Mon. weather rev. 44: 634–642.

ON THE MEASURE OF CORRELATION: A REJOINDER

By GILBERT T. WALKER

The note upon my article on the above subject by Mr. Edgar W. Woolard in the MONTHLY WEATHER REVIEW of October last, raises several points of interest, and I hope I may be allowed to make some comments.

1. The fundamental issue can best be seen in a numerical example. The longest series of forecasts known to me is that based on a formula of 1908 for monsoon forecasting in India. The departures of monsoon rainfall given on the 1st of June of the years 1909–1927 by the regression equation, i. e., the amounts determined by external factors, were:

1909	+1.4	1919	−0.7
1910	+1.3	1920	−2.0
1911	+0.7	1921	+2.6
1912	+2.1	1922	−0.2
1913	−0.6	1923	+1.5
1914	+0.7	1924	+0.5
1915	−1.0	1925	+0.8
1916	+4.5	1926	+1.1
1917	+2.9	1927	+1.4
1918	+0.2		

The actual departures during these years were:

1909	+1.9	1919	+3.2
1910	+2.0	1920	−4.3
1911	−3.2	1921	+1.4
1912	−1.1	1922	+2.0
1913	−1.7	1923	+1.5
1914	+3.4	1924	+3.1
1915	−3.0	1925	−1.6
1916	+5.0	1926	+3.6
1917	+7.1	1927	−1.6
1918	−6.5		

2. The S. D. of the first series is 1.73, and of the second is 3.44, the ratio of the first S. D. to the second being 0.50; while we find the correlation coefficient between the two series is 0.56. Now r^2 is 0.31, and I contend that in the long run the ratio of the first series to the second will be r, not r^2. This fraction must, in the long run, be the same in whatever reasonable way the two series are compared, for they obey the same distribution law. When it is said that I take the S. D. as the measure of variation, while Krichewsky takes the square of the S. D., the statement is, in effect, precisely equivalent to saying that I compare the actual series while Krichewsky compares their squares. I hold that if we compare 1, 2, 3, 4, 5, . . . with 2, 4, 6, 8, 10, . . . the first series is half the second and that we can not justify calling it a quarter (or an eighth) by saying that the square (or the cube) of the terms is considered.

3. I would like now to comment on some of the arguments used. When I state that a fraction $r\sigma_0$ of σ_0 is due to variations in x_1, I do not attribute "the remainder $(1-r)\ \sigma_0$ to variations in x_2, . . ." (p. 460). For if $x_0=p+q$, where p and q are independent, it is easily seen that the S. D.'s σ_p, σ_q, of p, q, satisfy the equation $\sigma_p^2+\sigma_q^2=\sigma_0^2$, not $\sigma_p+\sigma_q=\sigma_0$; so the S. D. of the remainder here must be $\sigma_0(1-r^2)$.[1]

On p. 461 there is a determination of the average value of the term $r\sigma_0\ \frac{x_1}{\sigma_1}$, which is accepted as the contribution from x_1. Now I gave in paragraph 4 on p. 460

what claims to be a mathematical demonstration that the standard deviation is $r\sigma_0$: It seems therefor rather doubtful whether the conditional argument "*If*, as frequently happens, B' is practically zero, then" Dines' Theorem would hold, can be said "to dispose of Walker's objection to Dines' Theorem."

DISCUSSION

There seems to me to be, in reality, no conflict between the ideas of Sir Gilbert Walker and those which I tried to express in my note to which he refers: That the ratio of the S. D.'s of the two series given by Walker should be r (if, as Walker assumes, b is independent of x_1) is, it will be found, stated in my note; it is also clear from my equation (2) that the mean of x_0/σ_0 will be r times the mean of x_1/σ_1. Any argument as to whether we should use the S. D. or its square as a measure or index of variation is futile; logically, we are free to use any measure we please, though in practise a particular one may be much more convenient for some purposes than any other; different measures will result in different theorems, but these can not be inconsistent, nor, as Walker rightly insists, alter any facts—nor will they, if strict attention be given to the adopted *meaning* of the terms used. For *certain purposes*, a discussion of which has not entered into these notes, Krichewsky found the square of the S. D. more convenient than the S. D. itself.

The theorem given by Walker in the last sentence of the first paragraph of section 3 of his note above is likewise explicitly accepted in my note; but the inconsistency implied by Walker does not exist, because the remainder of the S. D. is not the same thing as the S. D. of the remainder, and

$$\sigma_0 \equiv r\sigma_0 + (1-r)\sigma_0 = \sqrt{(r\sigma_0)^2 + [\sigma_0(1-r^2)^{1/2}]^2}.$$

In the second paragraph of section 3, Walker, by overlooking some essential phrases and italicized words, changes the intended sense of my statements to which he refers, and fails to reproduce the point I tried to make.

As F. J. W. Whipple observes in a recent note on this subject (Meteorological Magazine, 63, 12–14, 1928), the difficulty is in establishing that certain enunciated rules are equivalent to certain given equations. It was my principal object to establish several equations, which together result in several consistent theorems relating to different aspects of the question under discussion; which of these equations or theorems is most useful in appraising the value of a correlation coefficient doubtless depends on the purpose for which the coefficient is to be used.—*Edgar W. Woolard.*

NOTE

A copy of the above discussion was submitted to Sir Gilbert who replies as follows:

"I am sorry to learn from Mr. Woolard's remarks that I have at times failed to catch the meaning that he intended to convey, and glad that there is no fundamental difference between us.—*Gilbert Walker.*"

METEOROLOGICAL SUMMARY FOR SOUTHERN SOUTH AMERICA, FEBRUARY, 1928

By J. BUSTOS NAVARRETE

[Observatorio del Salto, Santiago, Chile]

During February the atmospheric circulation continued to show very moderate intensity; however, storms of some importance were beginning to appear over the southern region.

Two cyclonic storms are to be mentioned as important: That of the 13th–16th, which crossed the far southern region and was accompanied by generally foul weather in the southern zone with heavy winds and rain north to the coast of Arauco; and that of the 27th–29th, which passed over the region visited by the earlier storm and likewise brought unsettled weather and rain.

At Valdivia, which is one of the rainiest points on the western coast of South America, the total monthly precipitation was 3.84 inches [normal 2.80 inches—*Translator*] and the maximum amount in 24 hours, 2.16 inches on the 15th.

The anticyclones causing the periods of fine, settled weather were charted through the following periods: 2d to 10th, 9th to 12th, 16th to 20th, and 20th to 26th. The second HIGH remained stationary over Chiloe; the others moved from Chiloe toward northern Argentina.

In general temperatures were moderate in the central zone of Chile, but about the 22d there was a period of very warm weather with maximum temperatures around 91°–92° F. On the central coast there was considerable cloudiness and frequent occurrences of early morning fog.—*Transl. by W. W. R.*

METEOROLOGICAL SUMMARY FOR BRAZIL, FEBRUARY, 1928

By FRANCISCO DE SOUZA, Acting Director

[Directoria de Meteorologia, Rio de Janeiro]

Unusual activity characterized the movement of the atmosphere over the southern and central parts of the country. Eight anticyclones entered the southern part of the continent. Some of these pressure systems probably dominated conditions over considerable areas and had rather perceptible gradients, but with their advance the gradients weakened abruptly. The depressions of higher latitudes and that of the continent were very active, giving rise to a number of storms, mainly on the southern and middle coasts of Brazil.

Rainfall was generally light in the northern and central regions with deficiencies of 2.60 and 3.10 inches, respectively. In the southern region, however, there was abundant precipitation, the average monthly amount being 1.80 inches above the normal.

In the State of Bahia and in the northeastern part of the country the deficiency in rainfall was injurious to the sugar-cane crop and unfavorable for the planting of cotton, cereals, and vegetables. Cotton, coffee, sugar cane, tobacco, cereals, and vegetables, still suffering from drought, mainly at points in the central region of the country, were benefited by occasional rains and have now improved in general condition. In the south and in the region of the Amazon the condition of some of these crops is good.

At Rio Janeiro the greater part of the month was characterized by fine weather; there were about 10 days with unsettled weather and rain and on some of these thunderstorms and high winds occurred. The mean temperature and the mean minimum temperature were 1.1° F. above the normal and the excess of the mean maximum was greater, 1.8°. Temperatures above 95° were recorded in the suburbs.

There were frequent heavy showers during the last decade. Cloudiness was considerably below normal; the total duration of sunshine was 48 hours above the average. Southerly winds with occasional high velocities prevailed; on the 4th, 23d, and 26th the maximum velocity exceeded 45 miles per hour.—*Transl. W. W. R.*

NOTES

DOCTOR DORNO RETIRES FROM THE DAVOS METEOROLOGICAL-PHYSICAL OBSERVATORY

After 21 years' activity in organizing and developing the Meteorological-Physical Observatory at Davos, Switzerland, Dr. C. Dorno retired on April 1, 1928, at the age of 63.

The following communication from Doctor Dorno is self-explanatory:

During the period 1907–1922, the observatory was equipped and maintained out of my personal funds. From 1922–1926, the expenses for carrying on the work were met by the Swiss Institute for Mountain Physiology and Tuberculosis Investigations, the observatory remaining in my private possession. On October 1, 1926, the observatory was taken over by the above-named institute and Doctor Lindholm, chief meteorologist in the Swedish service and for many years assistant to Prof. K. Angström, was granted leave of absence by his Government to engage in the work of the institution.

I am leaving my life work confident that my earnest and energetic successor, after a year and a half of collaboration and counsel with myself, will remain conscientiously devoted to the comprehensive work of the observatory.

Thanks are due for the interest and encouragement shown in foreign lands. Foremost among these are Sweden, which was the pioneer in solar investigations and now gives me an esteemed successor, and the United States, whose Weather Bureau, through its chief, Prof. C. F. Marvin, and Dr. H. H. Kimball of the division of solar radiation investigations, and also several universities, have maintained close connection with the Davos Observatory and have manifested a lively interest in its work since the close of the World War.

There has been fine harmony in the relations and interchanges between the representatives of almost all civilized lands here convened and the modest little Hochgebirgsobservatorium—the first meteorological-physical observatory in long-continued operation. It was this continuity of observations which brought results in the field of atmospheric optics through the perception and proof that *summer*, utilized exclusively at other places, is the most *unfavorable* season.

The idea of an "applied meteorology," originally applied by me to "medical meteorology" and later changed to "physiological meteorology" (so as to include both the plant and animal kingdoms) has been adopted and is now spreading throughout the world.

Lightning from clear sky.—On July 2, 1927, Stanley Lukens, a forest ranger, was supervising the opening of the Gold Peak lookout on the Missoula National Forest. While Lukens and his assistant were setting up the fire finder they aimed the alidade at various prominent topographic features to check the orientation of the map. As they were making one of these test observations toward a point southeast of Gold Peak both men saw a flash of lightning strike the ground almost on their line of alidade sight, and about 15 miles from them. This flash was followed by four others within the next few minutes. The first strike started a forest fire, the others did not. The phenomenon was most peculiar because all of these strikes descended almost vertically, apparently out of a blue sky, the nearest clouds being about 15 and 25 miles, respectively, from the area struck.

Both Lukens and the lookout, a Mr. Wertz, were greatly impressed by this condition because their general impression was that at that time, 2:30 p. m., the sky was practically clear. A small thunderstorm had passed over Gold Peak between 7:50 and 8:15 a. m. that day, then the sky had cleared. Mr. Lukens remembers, however, that at the time of these "bolts from the blue," there were two small cumulo-nimbus clouds south and southwest, 30 to 40 miles from Gold Peak. These lightning bolts, all of which struck within a small area not over half a mile in diameter, appeared to descend almost vertically, and they were not between the two clouds, but in a northeasterly direction and over 15 miles from them.

No thunder was heard from these flashes, and no further bolts were seen. About half an hour after these strikes the cloud which had been south of Gold Peak passed over the struck area and delivered sufficient rain to extinguish the fire, which had been smoking appreciably. This cloud is reported by Mr. Lukens to have been about 1 to 1½ miles long by one-half to three-quarters of a mile wide, and was of the cumulus type.—*H. F. Gisborne.*

Range of atmospherics. (*Report from the Committee on Radiation on the Relation between Atmospherics and Weather. Roy. Met'l Soc. Jour., 53:327–388; discussion, pp. 389–400, Oct., 1927.*)[1]—The report deals with the results obtained by 48 observers listening to a broadcast talk and to which the time incidence of individual atmospherics can be referred.

[1] Reprinted from Science Abstracts.

The duration and intensity of the disturbances were noted. The data were tabulated to give (*a*) observations with complete simultaneity without adjustment, and (*b*) observations where one time unit allowance is allowed for the adjustment of the personal error. The place of origin of individual atmospherics was recorded and a "disturbance index" given, i. e., the relative number of atmospherics per unit time referred to 100 for the most disturbed evening. The weather in the region of the atmospheric "fixes" was found from weather charts. In some cases atmospherics were traced as originating at clearly defined cold fronts or regions of thunderstorm activity. It was concluded that (1) the effective range of reception of very many atmospherics heard on normal broadcast receivers exceeds 3,000 km. and reaches at least 7,000 km.; (2) atmospherics of range below 200 km. are not shown by any evidence; and (3) cold fronts are of great importance in the origination of atmospheric disturbance. In the Discussion, A. G. Lee described experiments showing that atmospherics which disturb long-distance commercial reception are not of short-distance origin, seeing that the distribution in azimuth is not uniform. J. A. Slee considered that for seagoing conditions most of the atmospherics heard were not of very long range. G. C. Simpson suggested the upper air as a source of atmospherics. R. Bureau supplied observations and diagrams to illustrate his view that atmospherics are a local consequence of instability. T. L. Eckersley suggested that some of the differences between the committee's results and those of Bureau might be due to differences of wave-length. The Committee replied to the discussion.—*R. S. R.*

Arctic Ice in 1927: The *Annual Report* by the Danish Meteorological Office on the state of the ice in Arctic Seas in 1927, has recently been published. In the Barents Sea the most noteworthy features were the congestion of ice off the entrance to White Sea from March until May, and the open sea up to Fraz Josef Land in September. The west coast of Novaya Zemlya was clear in July, and the Kara Sea was almost clear in August and quite clear in September. Around Spitzbergen there was much less ice than usual, except in October and November, when a broad belt of pack lay off the west coast. Bear Island, however, was not clear of ice from the autumn of 1926 until the end of May. On the east coast of Greenland the belt of ice seems, on the whole, to have been wider than usual, but the coasts of Iceland were free throughout the year. In Davis Strait there was less ice than usual, and on the Newfoundland Banks the ice season was short and had ended entirely by August. In Baffin Bay and the channels of the Canadian Arctic Archipelago, ice was scarcer than in most years. Davis Strait was almost clear in July, but Wrangel Island was not approachable until August. The report is furnished with the usual ice distribution charts for the spring and summer months. [Reprinted from *Nature*, London, April 14, 1928.]

March weather in the United States 50 years ago.—The weather of March, 1878, was noteworthy in at least two respects; first, atmospheric pressure was exceptionally low and temperature unusually high in the Missouri Valley and, second, the month, as a whole, was one of the warmest of that name ever experienced. A Missouri River steamboat passed Leavenworth, Kans., bound for Montana, on the 27th of March, arrived at Lower Brule Agency in the present State of South Dakota, on April 1, Fort Lincoln on the 9th, and Bismarck, N. Dak., on the 9th. Leaving that point on the 12th the steamer arrived at Fort Benton—the headwaters of navigation on the Missouri—on April 30, thus making the earliest trip ever accomplished, due to the open condition of the river and the freedom from ice.—*A. J. H.*

BIBLIOGRAPHY

C. FITZHUGH TALMAN, in Charge of Library

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Austin, L. W., & Wymore, I. J.
On the influence of solar activity on radio transmission. p. 166–173. figs. 23 cm. (Repr.: Proc. Inst. radio engin., Feb., 1928.)

Brooks, C. E. P.
Weather, an introduction to climatology. London. [1927.] 79 p. figs. 16½ cm.

Burton, C. O.
Recording wind velocity. Indianapolis. [1928.] v. p. illus. plates. 31 cm. [In part typewritten and manifolded.]

Cuba. Sec. de obras publicas.
Memoria de los trabajos efectuados con motivo del ultimo ciclon que azoto la isla el 20 de Octubre de 1926. n. p. 1927. xi, 154 p. plates (part fold.). 26½ cm.

Great Britain. Meteorological office.
Instructions to observers at climatological stations at health resorts. London. 1927. 7 p. 24½ cm. (Met'l observ. handbook (M. O. 191) Suppl. no. 4.)

Hamburg. Deutsche Seewarte.
Meteorologie aus dem Gebiete der See- und Küstenluftfahrt. Berlin. n. d. Heft 1. (Aufsätze und Mitteil. aus den "Annalen der Hydrog. und marit. Met., 1927. II. Halbj.)

Kolhörster, Werner, & Salis, Gubert von.
Die tägliche Periode der Höhenstrahlung. p. 92–104. figs. plate. 25½ cm. (Sitzungsb. preuss. Akad. d. Wissensch. XI. 1927.)

Montpelier, Vt.
Flood, November 3 and 4, 1927. [Montpelier. c1928.] unp. illus. 14 cm.

Naegler, Wilh.
Die strengen Winter in Leipzig von 1829 bis 1926. [Leipzig. 1926.] p. 271–286. 24½ cm. [Berichte über die Verh. der sächs. Akad. der Wissensch. zu Leipzig math.-phys. Kl. Bd. 27. 1926.]

Petersen, Helge.
Climate of Greenland. p. 257–276. figs. 25½cm. (Repr.: Greenland. v. 1.)

Puig, Ignacio.
El Observatorio del Ebro, idea general sobre el mismo. Tortosa. [1927.] viii, 188 p. illus. 24½ cm.

Robertson, C. L.
Variability of Rhodesian rainfall. p. 102–109. fig. 24 cm. (So. Afr. journ. sci. v. 24, Dec., 1927.)

Rouch, J.
Les applications de la météorologie pendant la guerre. p. 128–134. 27½ cm. (L'Armée d'Afrique. Alger. no. 34 (4e année) avril 1927.)

Russia. Central geophysical observatory.
Klima der Union der Sozialistischen Sowjet-Republiken. Leningrad. 1926. xii, 128 p. 35 cm. Teil 1. Lief. 1. Atlas. Teil 1. Die Lufttemperatur. Lief. 1. Monattsmittel der Lufttemperatur im Europäischen Teil der U. S. S. R. von Eugenie Rubenstein. Leningrad. 1927. 45 p. 53 cm. [Author, title and text in Russian and German.]

Shaw, William Napier.
Comparative meteorology ... Cambridge. 1928. xxxix, 445 p. illus. 27 cm. [Manual of meteorology, v. 2.]

Störmer, Carl.
Modern Norwegian researches on the aurora borealis. p. 139–147. fig. plates. 30 cm.

Werth, E.
Klima- und Vegetations-Gliederung in Deutschland. Berlin. 1927. 40 p. figs. plates. map in pocket. 24 cm. (Mitt. aus der Biologischen Reichsanstalt für Land- und Forstwirtschaft. Heft 33, Dez. 1927.)

SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING MARCH, 1928

By HERBERT H. KIMBALL, Solar Radiation Investigations

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1924, 52: 42, January, 1925, 53: 29, and July, 1925, 53: 319.

Table 1 shows that solar radiation intensities were slightly below the normal values for March at all three stations.

Table 2 shows a slight excess in the total solar radiation received on a horizontal surface directly from the sun and diffusely from the sky at the three stations for which monthly normals have been determined.

Skylight-polarization measurements at Washington made on three days give a mean of 60 per cent, with a maximum of 63 per cent on the 5th. These are close to the corresponding normal values for Washington for March. At Madison no polarization measurements were made during the month on account of the presence of ice and snow.

TABLE 1.—*Solar radiation intensities during March, 1928*

[Gram calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass, A. M.					Air mass, P. M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Mar. 5	2.06	0.91	1.06	1.20	1.32	......	1.25	0.89	0.74	0.62	1.52
Mar. 6	2.16	......	0.52	0.69	1.01	1.54	......	......	......	......	1.78
Mar. 15	5.16	......	0.72	0.88	......	......	......	......	......	......	4.75
Mar. 10	3.15	0.60	0.72	......	......	......	......	......	......	......	3.45
Mar. 23	4.37	0.80	0.90	1.03	1.18	1.35	1.05	0.89	0.76	0.68	4.75
Mar. 27	4.75	......	......	......	1.30	1.54	......	......	......	......	3.15
Mar. 29	5.16	......	......	0.49	......	......	......	......	......	......	5.33
Mar. 31	3.00	0.82	1.00	1.16	1.31	1.50	......	......	......	......	3.45
Means	......	0.78	0.82	0.91	1.22	1.48	(1.15)	(0.89)	(0.75)	(0.65)	......
Departures	......	+0.06	+0.03	−0.03	+0.07	......	+0.03	−0.04	−0.05	−0.04	......

Madison, Wis.

Date	8 a.m.	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	Noon
Mar. 1	2.06	......	......	1.17	......	......	......	......	......	......	2.49
Mar. 2	2.74	......	......	1.21	......	......	......	......	......	......	3.30
Mar. 3	1.78	......	1.00	......	1.34	1.57	......	......	......	......	1.78
Mar. 5	0.91	......	1.11	1.24	1.40	1.66	1.36	1.20	......	......	1.32
Mar. 7	2.36	......	......	......	1.29	1.61	1.02	......	......	......	1.96
Mar. 16	2.06	......	......	1.13	1.34	1.58	1.29	......	......	......	2.16
Mar. 17	2.36	......	......	......	1.18	......	......	......	......	......	4.17
Mar. 20	3.00	......	0.90	1.13	1.29	1.51	......	......	......	......	3.15
Mar. 21	3.00	......	......	0.97	1.20	......	1.19	......	......	......	4.57
Mar. 22	5.36	......	1.09	1.20	1.35	1.51	1.30	......	......	......	5.36
Mar. 23	4.75	......	......	......	......	......	1.00	......	......	......	7.57
Mar. 27	1.86	......	1.16	1.28	1.44	1.60	1.41	......	......	......	1.88
Mar. 30	2.87	......	......	......	......	1.57	1.34	......	......	......	2.36
Means	......	......	1.09	1.17	1.31	1.58	1.24	(1.20)	......	......	......
Departures	......	......	+0.04	−0.01	−0.01	......	−0.06	+0.03	......	......	......

Lincoln, Nebr.

Date	8 a.m.	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	Noon
Mar. 1	2.16	......	......	1.18	1.41	1.63	......	......	......	......	2.26
Mar. 2	1.88	......	1.02	1.20	1.35	......	......	......	......	......	2.87
Mar. 4	3.15	......	......	......	......	1.46	1.27	1.10	0.97	0.81	2.26
Mar. 6	2.87	......	......	......	......	1.33	1.15	0.98	0.89	0.76	4.37
Mar. 7	3.30	......	0.92	1.03	1.29	1.48	......	......	......	......	3.81
Mar. 9	4.17	......	......	......	......	1.42	1.25	1.05	0.90	0.80	3.63
Mar. 13	3.63	......	......	......	......	1.46	1.30	1.14	0.97	0.81	3.30
Mar. 16	2.36	......	......	......	......	......	......	1.09	0.94	0.78	1.68
Mar. 20	2.62	......	......	......	......	1.48	1.27	1.08	0.95	0.85	2.16
Mar. 21	3.45	0.73	0.92	1.06	1.17	1.53	1.20	1.02	0.87	0.70	4.75
Mar. 22	5.16	......	0.77	0.94	1.13	1.40	1.14	0.99	0.89	......	6.27
Mar. 23	5.79	0.87	0.98	1.10	1.27	1.51	......	......	......	......	6.27
Mar. 30	2.62	......	......	......	1.28	......	......	......	......	......	1.78
Means	......	(0.80)	0.92	1.08	1.27	1.47	1.23	1.06	0.92	0.79	......
Departures	......	−0.06	−0.03	−0.02	−0.02	......	−0.05	−0.03	−0.02	−0.03	......

[1] Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface*

[Gram-calories per square centimeter of horizontal surface]

Week beginning—	Average daily radiation: Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Average daily departure from normal: Washington	Madison	Lincoln
1928	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Feb. 26	312	346	408	258	292	260	+17	+55	+59
Mar. 4	349	259	368	168	303	234	+36	−35	+19
Mar. 11	228	312	352	195	219	303	−101	+12	−23
Mar. 18	399	424	417	326	286	305	+39	+89	+6
Mar. 25	395	378	361	214	240	160	+44	+47	−46
Excess or deficiency since first of year on Mar. 31							+434	+665	−665

POSITIONS AND AREAS OF SUN-SPOTS

[Communicated by Capt. C. S. Freeman, Superintendent U. S. Naval Observatory]

[Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, and Mount Wilson Observatories]

(The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column)

Date	Eastern standard civil time	Heliographic: Diff. long.	Longitude	Latitude	Area: Spot	Group	Total area for each day
1928	h. m.	°	°	°			
Mar. 1 (Naval Observatory)	12 1	−35.0	315.4	−8.0	......	37	......
		−26.5	323.9	−5.5	247	......	......
		−14.5	335.9	−19.5	31	......	......
		−9.0	341.4	−19.5	22	......	......
		−4.0	346.4	−19.0	......	31	......
		+48.0	38.4	−8.5	108	......	......
		+49.0	39.4	−19.0	31	......	......
		+60.0	50.4	−3.5	......	216	......
		+67.5	57.9	−3.0	......	139	......
		+69.0	59.4	−11.0	......	185	......
		+76.0	66.4	−12.5	370	......	1,417
Mar. 2 (Naval Observatory)	11 41	−19.5	317.9	−8.0	......	31	......
		−12.5	324.9	−5.5	216	......	......
		−1.0	336.4	−19.0	31	......	......
		+4.5	341.9	−19.0	15	......	......
		+8.0	345.4	−19.0	......	31	......
		+60.5	37.9	−9.0	123	......	......
		+61.0	38.4	−10.0	31	......	......
		+72.0	49.4	−3.5	......	216	......
		+80.0	57.4	−3.0	......	123	......
		+83.0	60.4	−11.0	......	185	1,002
Mar. 3 (Naval Observatory)	11 58	−55.0	269.1	+8.5	......	46	......
		−8.0	316.1	−8.5	......	31	......
		+1.0	325.1	−5.5	216	......	......
		+12.0	336.1	−19.0	31	......	......
		+18.5	342.6	−19.0	15	......	......
		+22.0	346.1	−18.5	......	31	......
		+73.0	37.1	−9.0	123	......	493
Mar. 4 (Naval Observatory)	11 49	−74.0	237.0	+17.5	......	185	......
		−42.0	269.0	+8.0	......	123	......
		−41.0	270.0	+10.5	......	15	......
		+4.5	315.5	−8.0	......	22	......
		+13.0	324.0	−5.5	216	......	......
		+25.0	336.0	−19.0	......	15	......
		+36.0	347.0	−18.5	......	9	585
Mar. 5 (Naval Observatory)	11 44	−64.0	233.8	+17.5	......	154	......
		−59.5	238.3	+17.0	......	185	......
		−28.5	269.3	+8.5	......	154	......
		−24.0	273.8	+6.5	108	......	......
		+19.0	316.8	−8.0	......	31	......
		+27.5	325.3	−5.5	216	......	848
Mar. 6 (Naval Observatory)	11 44	−60.0	224.6	−10.5	46	......	......
		−48.0	236.6	+17.5	......	154	......
		−43.0	241.6	+15.0	......	108	......
		−17.5	267.1	+8.5	......	154	......
		−11.0	273.6	+5.5	......	154	......
		+17.5	302.1	+27.5	......	62	......
		+39.5	324.1	−5.0	201	......	879
Mar. 7 (Naval Observatory)	11 45	−45.5	226.0	−10.0	9	......	......
		−38.0	233.5	+17.5	......	46	......
		−30.5	241.0	+15.0	......	139	......
		−6.0	265.5	−20.0	......	6	......
		−2.5	269.0	+7.5	......	154	......
		+3.5	275.0	+5.5	......	139	......
		+30.0	301.5	+27.0	......	123	......
		+52.0	323.5	−5.0	216	......	......
		+63.0	334.5	−9.0	6	......	838
Mar. 8 (Naval Observatory)	11 46	−31.0	227.3	−10.0	12	......	......
		−25.0	233.3	+17.5	......	62	......
		−17.0	241.3	+15.0	......	123	......
		+12.0	270.3	+8.5	......	370	......
		+18.5	276.8	+5.5	......	185	......
		+40.0	298.3	+28.5	77	......	......
		+45.0	303.3	+27.0	......	46	......
		+65.0	323.3	−4.5	185	......	......
		+73.0	331.3	−8.5	46	......	1,106

Positions and areas of sun-spots—Continued

Date	Eastern standard civil time		Heliographic			Area		Total area for each day
			Diff. long.	Longitude	Latitude	Spot	Group	
1928	h.	m.	°	°	°			
Mar. 9 (Mount Wilson)	14	30	−83.0	160.6	−19.0	499		
			−44.0	199.6	−15.0	5		
			−22.0	221.6	−9.0		11	
			−17.0	226.6	−10.0	4		
			−2.0	241.6	+15.0		149	
			+29.0	272.6	+7.0		548	
			+57.0	300.6	+26.0		52	
			+81.0	324.6	−5.0	122		1,390
Mar. 10 (Naval Observatory)	12	45	−70.0	161.4	−19.0	309		
			−9.0	222.4	−8.0		93	
			−3.5	227.9	−10.0	6		
			+2.5	233.9	+18.0		31	
			+8.0	239.4	+17.0		108	
			+12.5	243.9	+15.0		62	
			+39.0	270.4	+10.5		586	
			+43.0	274.4	+5.0		62	
			+48.0	279.4	+7.0	123		1,380
Mar. 11 (Harvard)	14	5	−81.0	136.5	−22.5	344		
			−55.0	162.5	−19.5	392		
			+8.0	225.5	−7.5		257	
			+25.5	243.0	+17.0		287	
			+58.0	275.5	+9.0		1,370	2,650
Mar. 12 (Naval Observatory)	13	25	−74.0	130.7	−22.0		617	
			−44.5	160.2	−19.0	231		
			+13.0	217.7	−18.0		62	
			+17.5	222.2	−8.5		46	
			+21.0	225.7	−9.0	170		
			+37.5	242.2	+17.0		247	
			+66.0	270.7	+11.0		586	
			+74.0	278.7	+7.0		216	2,175
Mar. 13 (Naval Observatory)	14	42	−83.0	107.8	+10.5	309		
			−69.0	121.8	+15.0		154	
			−67.0	123.8	−23.0		62	
			−61.0	129.8	−22.0		494	
			−31.0	159.8	−19.5	216		
			+24.0	214.8	−19.0		46	
			+31.0	221.8	−18.5	62		
			+35.5	226.3	−9.0	185		
			+48.0	238.8	+18.5		62	
			+53.5	244.3	+16.0		123	
			+79.0	269.8	+12.0		463	2,176
Mar. 14 (Naval Observatory)	11	54	−72.0	107.2	+10.5		432	
			−61.5	117.7	+16.5	93		
			−54.0	125.2	+15.0	108		
			−53.0	126.2	−23.5		93	
			−48.5	130.7	−22.0		370	
			−45.0	134.2	−17.5	15		
			−19.0	160.2	−20.0	201		
			+35.0	214.2	−20.0	9		
			+43.5	222.7	−17.5	139		
			+47.5	226.7	−9.0	170		
			+68.0	247.2	+15.0	93		1,723
Mar. 15 (Naval Observatory)	12	2	−57.5	108.4	+10.0		340	
			−48.0	117.9	+16.0	170		
			−39.0	126.9	+14.5	247		
			−38.5	127.4	−22.5		62	
			−35.5	130.4	−22.0		340	
			−29.5	136.4	−14.5		62	
			−6.5	159.4	−20.0		201	
			+57.0	222.9	−18.0	123		
			+60.5	226.4	−9.0	216		1,761
Mar. 16 (Harvard)	10	54	−41.0	112.5	+9.0		476	
			−28.5	125.0	+15.0		470	
			−20.0	133.5	−23.0		456	
			−13.5	140.0	−14.5		221	
			+8.5	162.0	−21.5		236	
			+73.0	226.5	−17.5	185		
			+76.5	230.0	−8.5	174		2,218
Mar. 17 (Harvard)	14	9	−25.0	113.5	+8.5		368	
			−12.5	126.0	+16.0		651	
			−4.5	134.0	−22.0		284	
			+2.0	140.5	−14.0		122	
			+23.5	162.0	−19.5	117		1,542
Mar. 18 (Naval Observatory)	12	43	−65.5	60.5	−5.5	15		
			−16.0	110.0	+8.5		386	
			−7.5	118.5	+17.5		154	
			+1.5	127.5	+14.5		401	
			+4.0	130.0	−22.5		278	
			+10.5	136.5	−16.5		93	
			+25.0	151.0	−13.5		62	
			+32.5	158.5	−20.5		77	
			+60.0	186.0	+16.0		9	
			+63.5	189.5	+2.5	15		1,490
Mar. 19 (Naval Observatory)	11	40	−2.5	110.8	+8.5		370	
			+7.0	120.3	+17.5		123	
			+14.5	127.8	+15.0		463	
			+16.0	129.3	−22.5		309	
			+22.5	135.8	−16.5		46	
			+39.0	152.3	−14.0		216	
			+45.5	158.8	−20.5	77		
			+50.5	163.8	−20.5	9		1,613
Mar. 20 (Naval Observatory)	11	48	+10.5	110.6	+9.0		340	
			+18.0	118.1	+17.5	62		
			+26.5	126.6	+15.5		525	
			+29.5	129.6	−23.0		309	
			+30.0	130.1	−15.0		31	
			+40.5	140.6	−14.5		77	
			+56.0	156.1	−13.5		154	
			+59.0	159.1	−20.5	77		1,675
Mar. 21 (Naval Observatory)	11	45	−25.5	61.5	−5.5		31	
			+24.0	111.0	+9.0		340	
			+30.5	117.5	+17.5	46		
			+37.0	124.0	+17.5		154	
Mar. 21 (continued)	11	45	+41.0	128.0	+15.0	309		
			+42.5	129.5	−23.0		247	
			+61.0	148.0	−14.5	62		
			+69.5	156.5	−13.0	185		
			+71.5	158.5	−20.0	77		1,451
Mar. 22 (Naval Observatory)	11	37	−68.5	5.3	+19.5		185	
			−11.0	62.8	−6.5		46	
			+37.5	111.3	+8.5		370	
			+43.5	117.3	+17.0	31		
			+50.5	124.3	+16.5		185	
			+55.0	128.8	+15.0	309		
			+56.0	129.8	−23.0		216	
			+83.0	156.8	−13.5		185	1,527
Mar. 23 (Naval Observatory)	11	43	−86.0	334.6	−13.0		216	
			−72.5	348.1	−9.5	154		
			−54.0	6.6	+19.5		154	
			+1.5	62.1	−6.5		31	
			+51.0	111.6	+9.0		370	
			+63.5	124.1	+17.0		216	
			+67.5	128.1	+15.0	340		
			+68.5	129.1	−23.0		185	1,666
Mar. 24 (Naval Observatory)	11	39	−80.5	326.9	−19.0		93	
			−72.5	334.9	−12.5		216	
			−60.0	347.4	−10.0	139		
			−39.5	7.9	+20.0		108	
			+14.5	61.9	−6.5		15	
			+63.5	110.9	+9.0	309		
			+80.0	127.4	+16.5		340	
			+82.0	129.4	−23.0		247	1,467
Mar. 25 (Naval Observatory)	11	43	−69.0	325.2	−1.0		19	
			−67.0	327.2	−19.0		77	
			−59.5	334.7	−13.0		216	
			−47.0	347.2	−11.0	108		
			−27.0	7.2	+19.5		93	
			+4.5	38.7	−9.5		9	
			+78.0	112.2	+9.0	247		769
Mar. 26 (Naval Observatory)	11	47	−55.0	326.0	−1.5	9		
			−52.5	328.5	−19.5		62	
			−45.5	335.5	−13.0		201	
			−33.5	347.5	−11.0	93		
			−12.5	8.5	+19.5		77	442
Mar. 27 (Naval Observatory)	13	28	−80.0	286.9	+22.0		247	
			−72.5	294.4	+7.5	77		
			−39.0	327.9	−19.5		62	
			−30.5	336.4	−13.5		216	
			−19.0	347.9	−11.0	108		
			+0.5	7.4	+19.5		62	772
Mar. 28 (Naval Observatory)	11	41	−68.0	286.7	+22.0		309	
			−60.0	294.7	+7.5	77		
			−28.5	326.2	−1.0	9		
			−27.5	327.2	−19.5		46	
			−18.0	336.7	−13.0		154	
			−7.0	347.7	−11.0	108		
			+12.0	6.7	+19.5		15	718
Mar. 29 (Naval Observatory)	13	16	−69.5	271.1	+10.5	123		
			−58.5	282.1	+22.0		154	
			−52.5	288.1	+23.0	154		
			−46.5	294.1	+7.5	62		
			−3.5	337.1	−12.5		139	
			+7.0	347.6	−11.0	93		725
Mar. 30 (Mount Wilson)	13	46	−55.0	272.4	+9.5	72		
			−39.0	288.4	+21.0		305	
			−32.0	295.4	+6.0	51		
			0.0	327.4	−19.5		25	
			+10.0	337.4	−13.0		138	
			+20.0	347.4	−12.5		169	760
Mar. 31 (Naval Observatory)	11	45	−43.0	272.0	+10.0	62		
			−33.5	281.5	+21.0		46	
			−26.5	288.5	+22.0		170	
			−20.0	295.0	+9.5		31	
			−19.5	295.5	+6.0	31		
			+15.0	330.0	−18.5		19	
			+22.5	337.5	−13.0		93	
			+33.5	348.5	−11.0	108		560
Mean daily area for March								1,284

PROVISIONAL SUN SPOT RELATIVE NUMBERS FOR MARCH, 1928

[Data furnished by Prof. A. Wolfer, University of Zurich, Switzerland]

March	Relative numbers	March	Relative numbers	March	Relative numbers
1	79	11		21	81
2	70	12	108	22	99
3	55	13		23	60
4	52	14		24	
5	70	15		25	71
6	76	16	109	26	59
7	91	17	103	27	
8		18	116	28	50
9		19	139	29	72
10		20	105	30	62
				31	53

Number of observations, 22; mean, 80.5.

AEROLOGICAL OBSERVATIONS

By W. R. STEVENS

Free-air temperatures for March were slightly below normal at Due West and Royal Center, and were mostly above at Broken Arrow, Ellendale, Groesbeck, and Washington. Highest March temperatures of record for various levels occurred at Broken Arrow, Ellendale, and Groesbeck, and lowest March temperatures of record at Broken Arrow, Due West, and Groesbeck.

Relative humidities and vapor pressures were near normal.

From the surface to 1,000 meters, resultant winds were of northerly component north of the latitude of St. Louis and east of the longitude of Salt Lake City. Above this altitude the area over which winds of southerly component prevailed gradually diminished with height and finally disappeared entirely at 5,000 meters.

Easterly winds at high levels were reported at various balloon stations west of the Mississippi River from the 17th to the 21st. As is usually the case with this condition, there was a notable lack of cyclonic activity over this area during that period.

Sounding balloons were released at 12 stations distributed over the southern half of the country at 8 p. m. of the 14th, and 8 a. m. and 8 p. m. of the 15th (75 meridian time). During this period special observations were made at all the kite and balloon stations. Airplane flights were obtained at five stations through cooperation with the Navy. These observations were made for the purpose of making a special study of cyclonic convection in the South and a detailed report will be made at a later date.

A kite ascent of special interest was obtained at Royal Center on the morning of the 26th when that station was under the influence of a LOW of marked intensity central at 8 a. m. over Springfield, Ill. Its movement east-northeastward was attended by numerous thunderstorms from the Lake region southward to Florida. At the beginning of the flight there was a large temperature inversion from the surface to 765 meters and a drop in relative humidity from 97 to 24 per cent. Before the end of the flight, however, there had been a rise in temperature at the surface, importation of colder air aloft, and an increase in relative humidity to nearly saturation. Aerological records show that thunderstorms are very frequently preceded by an importation of colder air aloft which aids in establishing the instability necessary for their genesis.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during March, 1928*

TEMPERATURE (°C.)

Altitude M. S. L. (meters)	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)		Washington, D. C. (7 meters)[1]	
	Mean	Departure from 10-yr. mean	Mean	Departure from 8-yr. mean	Mean	Departure from 11-yr. mean	Mean	Departure from 10-yr. mean	Mean	Departure from 10-yr. mean	Mean	Departure from 3-yr. mean
Surface	9.6	−0.3	10.6	−1.4	1.0	+3.2	14.4	+1.1	3.3	−0.7	9.4	+3.0
250	9.5	−0.3	10.3	−1.4			13.7	+1.0	3.1	−0.7	7.2	+2.3
500	8.7	+0.6	8.8	−1.1	0.8	+3.2	12.6	+1.1	1.2	−0.6	5.2	+1.6
750	7.8	+0.9	7.8	−0.7	−0.5	+2.7	12.1	+1.5	−0.1	−0.7	3.7	+1.2
1,000	6.9	+0.9	6.7	−0.6	−2.0	+1.7	11.7	+1.7	−0.7	−0.6	2.7	+1.3
1,250	5.8	+0.5	5.3	−0.8	−2.7	+1.6	10.9	+1.5	−1.2	−0.5	1.8	+1.6
1,500	4.8	+0.2	4.1	−0.8	−3.5	+1.4	10.2	+1.4	−1.7	−0.3	1.0	+1.8
2,000	2.7	−0.2	2.1	−0.6	−5.4	+1.2	8.0	+0.6	−4.1	−1.1	−1.4	+1.4
2,500	0.5	−0.1	−0.4	−0.9	−8.4	+0.6	5.0	−0.2	−6.6	−1.4	−3.7	+1.1
3,000	−2.0	−0.1	−3.3	−1.6	−11.6	+0.1	1.8	−0.8	−9.3	−1.7	−5.3	+1.9
3,500	−4.1	+0.3	−3.6	−0.5	−14.6	−0.2	−1.7	−1.5	−11.6	−1.6		
4,000	−6.1	+1.1			−17.4	−0.3	−5.3	−2.1	−14.3	−1.7		
4,500	−9.3	+0.7			−21.8	−1.7	−9.3	−3.3	−16.9	−1.5		
5,000					−26.0	−3.0						

RELATIVE HUMIDITY (%)

Altitude M. S. L. (meters)	Broken Arrow Mean	Departure	Due West Mean	Departure	Ellendale Mean	Departure	Groesbeck Mean	Departure	Royal Center Mean	Departure	Washington Mean	Departure
Surface	64	0	62	−1	62	−10	69	−1	70	−1	61	−4
250	64	0	61	−2			70	+1	70	−1	63	−2
500	59	−4	58	−4	61	−10	70	+3	70	0	64	−1
750	56	−6	58	−3	59	−8	66	+2	66	−2	62	−1
1,000	54	−7	57	−4	59	−4	61	+1	61	−3	61	−1
1,250	52	−6	58	−3	56	−3	56	0	55	−5	61	−1
1,500	50	−4	55	−5	56	−1	55	+3	49	−8	59	−2
2,000	48	+1	51	−5	52	−3	49	+6	46	−8	54	−2
2,500	45	+2	48	−3	50	−5	48	+9	48	−5	53	+1
3,000	43	+2	43	−2	51	−5	50	+13	51	−2	59	+10
3,500	44	+5	27	−15	49	−6	51	+15	50	−1		
4,000	46	+8			39	−14	53	+15	51	+1		
4,500	48	+11			43	−9	54	+14	56	+3		
5,000					55	+3						

VAPOR PRESSURE (mb.)

Altitude M. S. L. (meters)	Broken Arrow Mean	Departure	Due West Mean	Departure	Ellendale Mean	Departure	Groesbeck Mean	Departure	Royal Center Mean	Departure	Washington Mean	Departure
Surface	7.66	−0.52	8.23	−1.21	4.03	+0.16	11.47	+0.06	5.78	−0.40	8.20	+1.13
250	7.56	−0.54	8.14	−1.16			11.12	+0.20	5.72	−0.36	7.32	+0.84
500	6.53	−0.64	7.18	−1.15	3.94	+0.18	10.34	+0.51	5.03	−0.22	6.54	+0.62
750	5.66	−0.79	6.58	−0.99	3.43	+0.15	9.37	+0.48	4.25	−0.43	5.67	+0.31
1,000	5.07	−0.88	6.23	−0.73	3.00	+0.05	8.39	+0.41	3.78	−0.43	5.15	+0.28
1,250	4.46	−0.92	5.69	−0.68	2.68	−0.01	7.36	+0.34	3.37	−0.43	4.83	+0.37
1,500	4.01	−0.78	4.93	−0.77	2.56	+0.07	6.97	+0.80	2.96	−0.47	4.39	+0.32
2,000	3.20	−0.47	3.77	−0.66	2.11	0.00	5.36	+0.89	2.51	−0.39	3.06	−0.02
2,500	2.53	−0.36	2.94	−0.37	1.57	−0.17	4.36	+0.92	2.18	−0.27	2.14	−0.14
3,000	1.94	0.38	2.20	−0.11	1.22	−0.17	3.65	+0.90	1.91	−0.20	1.83	+0.12
3,500	1.72	0.14	1.32	−0.34	0.77	−0.31	2.98	+0.74	1.49	−0.13		
4,000	1.37	−0.04			0.32	−0.51	2.31	+0.40	1.23	−0.00		
4,500	0.77	−0.30			0.00	−0.65	1.70	−0.04	1.11	−0.02		
5,000												

[1] Naval Air Station, Washington, D. C.

TABLE 2.—*Free-air resultant winds (m. p. s.) during March, 1928*

Altitude m. s. l. (meters)	Broken Arrow, Okla. (233 meters) Mean Dir.	Mean Vel.	10-year mean Dir.	10-year mean Vel.	Due West, S. C. (217 meters) Mean Dir.	Mean Vel.	8-year mean Dir.	8-year mean Vel.	Ellendale, N. Dak. (444 meters) Mean Dir.	Mean Vel.	11-year mean Dir.	11-year mean Vel.
	°		°		°		°		°		°	
Surface	S. 5 W.	0.1	S. 17 W.	1.7	N. 86 W.	1.6	S. 72 W.	1.7	N. 35 W.	2.1	N. 43 W.	2.0
250	S. 22 W.	.1	S. 16 W.	1.9	W.	1.7	S. 74 W.	1.8				
500	S. 42 W.	.8	S. 20 W.	3.0	S. 86 W.	2.6	S. 74 W.	3.0	N. 43 W.	2.2	N. 47 W.	2.0
750	S. 84 W.	1.0	S. 26 W.	3.7	N. 86 W.	3.1	S. 77 W.	4.1	N. 47 W.	3.5	N. 64 W.	2.6
1,000	S. 85 W.	1.6	S. 37 W.	4.3	N. 83 W.	4.8	S. 76 W.	5.4	N. 53 W.	4.4	N. 73 W.	3.2
1,250	N. 73 W.	1.7	S. 52 W.	4.9	N. 81 W.	7.0	S. 77 W.	6.7	N. 61 W.	5.4	N. 71 W.	4.0
1,500	N. 81 W.	2.5	S. 67 W.	5.4	N. 81 W.	8.2	S. 79 W.	8.4	N. 61 W.	6.0	N. 74 W.	5.1
2,000	N. 80 W.	4.2	S. 80 W.	6.6	N. 80 W.	12.2	S. 83 W.	10.9	N. 64 W.	6.9	N. 74 W.	6.9
2,500	N. 78 W.	6.1	W.	8.0	N. 80 W.	14.2	S. 89 W.	12.4	N. 71 W.	8.6	N. 74 W.	9.0
3,000	N. 88 W.	8.7	N. 89 W.	9.5	N. 72 W.	12.6	S. 86 W.	13.8	N. 70 W.	9.6	N. 75 W.	10.9
3,500	S. 73 W.	9.6	S. 81 W.	10.4	N. 55 W.	12.0	S. 87 W.	14.3	N. 77 W.	9.2	N. 81 W.	12.3
4,000	S. 49 W.	13.1	S. 75 W.	11.3					S. 86 W.	11.8	N. 88 W.	13.7
4,500	S. 53 W.	13.6	S. 67 W.	13.2					S. 82 W.	13.8	N. 88 W.	14.4
5,000									S. 45 W.	14.0	N. 86 W.	15.4

Altitude m. s. l. (meters)	Groesbeck, Tex. (141 meters) Mean Dir.	Mean Vel.	10-year mean Dir.	10-year mean Vel.	Royal Center, Ind. (225 meters) Mean Dir.	Mean Vel.	10-year mean Dir.	10-year mean Vel.	Washington, D. C. (34 meters) Mean Dir.	Mean Vel.	8-year mean Dir.	8-year mean Vel.
	°		°		°		°		°		°	
Surface	S. 50 W.	0.5	S. 6 E.	0.9	S. 85 W.	2.2	S. 54 W.	1.7	N. 64 W.	1.9	N. 49 W.	1.6
250	S. 11 W.	.8	S. 8 E.	1.5	S. 83 W.	2.5	S. 49 W.	1.8	N. 76 W.	4.3	N. 77 W.	3.3
500	S. 26 W.	2.0	S. 6 W.	3.0	S. 84 W.	5.0	S. 58 W.	4.1	N. 74 W.	7.1	N. 76 W.	5.2
750	S. 28 W.	2.7	S. 21 W.	3.6	N. 89 W.	6.4	S. 64 W.	5.3	N. 63 W.	9.0	N. 71 W.	6.3
1,000	S. 37 W.	3.5	S. 35 W.	4.3	N. 87 W.	7.2	S. 70 W.	6.0	N. 71 W.	10.2	N. 68 W.	7.1
1,250	S. 68 W.	4.5	S. 47 W.	4.8	N. 85 W.	8.4	S. 77 W.	7.2				
1,500	S. 73 W.	5.8	S. 52 W.	5.3	N. 81 W.	9.9	S. 83 W.	8.2	N. 71 W.	11.9	N. 67 W.	8.8
2,000	S. 83 W.	7.6	S. 64 W.	6.6	N. 79 W.	12.3	S. 88 W.	9.8	N. 74 W.	13.0	N. 70 W.	10.3
2,500	S. 82 W.	9.1	S. 68 W.	8.5	N. 77 W.	12.6	S. 89 W.	10.7	N. 72 W.	13.9	N. 67 W.	9.9
3,000	S. 78 W.	9.8	S. 72 W.	9.4	N. 73 W.	12.5	N. 86 W.	13.0	N. 82 W.	13.9	N. 73 W.	10.2
3,500	W.	11.4	S. 76 W.	12.2	N. 69 W.	11.4	N. 88 W.	14.1				
4,000	S. 80 W.	16.3	S. 71 W.	14.3	N. 68 W.	13.7	N. 86 W.	13.1				
4,500	S. 77 W.	17.0	S. 81 W.	14.1	N. 42 W.	15.1	N. 82 W.	11.2				
5,000					N. 32 W.	17.4	N. 83 W.	11.3				

WEATHER IN THE UNITED STATES

THE WEATHER ELEMENTS

By P. C. DAY

GENERAL CONDITIONS

March, like the preceding months of 1928, was mainly without the tempestuous character ordinarily associated with the weather of the first part of the year over the more northern districts, and for the country as a whole it was unusually favorable for the outdoor operations common to the season.

PRESSURE AND WINDS

While changes from warm to cool and from cyclonic to anticyclonic conditions were fairly frequent they were usually not of extensive proportions and the month lacked much of the rough weather usually associated with the period attending the end of winter and the beginning of spring.

The first cyclone giving important precipitation over an extensive area formed over the Southwest about the 7th. By the following morning it had moved to the middle Missouri Valley with light precipitation over a small area near the center, but by the morning of the 9th the center had moved to northern Ohio, and the precipitation area had overspread a large part of the country from the Great Plains eastward, some heavy snows occurring in the upper Lake region and local heavy rains in the southern Appalachian region. During the following day the precipitation area extended to the Atlantic coast with some heavy local rains over the Middle Atlantic States. At the same time an extensive precipitation area had overspread the far Northwest continuing for several days, the rainfall being heavy at times near the coast, with occasional snows in the adjacent mountains.

On the 15th a second cyclone having its origin in the far Southwest had moved to the lower Rio Grande Valley and precipitation, mostly snow, had fallen in the Rocky Mountain region from western Montana southward and had extended into the southern Plains. During the following 24 hours the center moved to northern Alabama and the precipitation area advanced eastward to the Atlantic coast with a secondary depression of the barometer extending southward into the Gulf of Mexico. Heavy rains had fallen in the west Gulf States and near-by areas with local snows in the lower Ohio Valley. By the morning of the 17th the secondary cyclone had advanced into northern Florida displacing the primary storm and during the following two or three days it moved slowly northward along the coast, increasing in severity and attended by local sleet and some heavy snows over districts removed from the coast, finally reaching northern New England and the Canadian Maritime Provinces by the morning of the 19th.

The first half of the third decade was mainly without important precipitation from the Rocky Mountains eastward, but by the 26th cyclonic conditions became established in the central valleys and precipitation had occurred in numerous sections from the Mississippi Valley eastward with local snows in the upper Lake region. During the following day the precipitation area extended rather generally into the more eastern districts, though little rain or snow occurred over the districts from Maryland and eastern Virginia to central and southern New England.

Closely following the cyclone last mentioned, another formed over the middle Rocky Mountain area and by the morning of the 28th it was central over Kansas. During the following 24 hours it moved to Arkansas, but without precipitation of consequence save light snows over a narrow area from Colorado and Nebraska to southern Lake Michigan. By 8 a. m. of the 30th this storm had developed materially and was central over western Pennsylvania, attended by local heavy rain in the Ohio Valley and to the southward, and by snow, sleet, or glaze in the lower Missouri Valley and thence eastward to southern Michigan and northern Ohio, the glaze becoming heavy and destructive over the northern parts of Indiana and Ohio and near-by portions of adjacent States, causing much damage to overhead wires, trees, shrubs, etc. This storm continued its course toward New England and the Canadian Maritime Provinces during the 31st, but with diminishing intensity.

Over the far Western States there was rather frequent precipitation during the first half of the month. There was generally little from the 15th to 20th, but during the last decade showers were frequent, particularly near the middle of the decade when wide areas had important rains in the lower elevations and considerable snow on the high mountains.

Anticyclones were mainly unimportant and brought no decided weather changes save on the 5th and 6th when a high-pressure area moving from the Canadian Northwest to the Great Lakes and Atlantic coast caused sharp falls in temperature up to 40° or more over these areas. Also about the 14th a "high" moved into the Dakotas and then advanced to the eastward and southward bringing the lowest temperatures of the month over extensive areas in the Southwest and eastward over the Gulf States during the following few days. An anticyclone that first appeared of small importance when over the upper Missouri Valley on the 26th caused an unusually wide and extensive fall in temperature within the following 24 hours from central Texas northeast to the Great Lakes, though, on account of the generally higher temperatures prevailing prior thereto it did not bring the lowest temperatures of the month.

The paths pursued by cyclones and anticyclones are presented in Charts II and III, respectively.

The average atmospheric pressure for the month is shown on Chart VI, while the departures from normal and changes from the values of the month preceding appear as insets to Charts II and III.

The prevailing wind directions also are shown on Chart VI and the notes concerning wind, hail, and other severe weather disturbances appear at the end of this section.

TEMPERATURE

Like the preceding months of the year, March was mainly warm with no important periods of outstanding variations from the means and extremes of other years. As in January and to a considerable extent in February the temperatures were decidedly high over the western two-thirds of the country and comparatively near normal in the eastern third.

The first week was mainly cooler than normal over the districts east of the Mississippi River, and moderately warmer in the districts to the westward. No important cold entered the more southern districts though the lowest temperatures of the month occurred over many of the northern and interior districts, readings of 20° to

30° or more below zero occurring at exposed points in the Rocky Mountain region, the upper Lakes, and Wyoming. northern New England, the lowest, −37°, occurring in

The second week was warmer than normal over all parts save the more northeastern States, and along the northern border from North Dakota eastward to the upper Lakes. This period was decidedly warm, plus 8° to 12°, from the middle Mississippi Valley northwestward to the Canadian boundary. The week ending March 20 averaged moderately cool over most central and eastern districts and continued mild in the far West, portions of Montana and North Dakota having averages from 5° to nearly 10° warmer than normal.

The week ending the 27th was distinctly warm on the whole, all parts save Florida having averages above normal, the excesses ranging up to 10° or 15° over much of the interior and Northwest. The highest temperatures of the month were recorded during this period over nearly all parts save along the South Atlantic and Gulf coasts where the warmest days were mainly the 28th to 30th. At some points in Montana the highest temperatures ever reported in March occurred on the 21st.

PRECIPITATION

March, like the two preceding months, was distinctly dry, in fact the greater part of the area from the Rocky Mountains eastward had deficient moisture compared with the normal for the month, the chief exceptions being portions of central Alabama, southern Georgia, and northern Florida, where there were locally some important excesses.

Over the far Western States the precipitation was mainly above normal and was usually favorably distributed.

The general absence of rainy days associated with moderate temperatures and lack of important snow cover over most eastern and central districts afforded unusually favorable conditions for the rapid progress of most outdoor occupations.

SNOWFALL

There was a rather wide distribution of snowfall, though the amounts were mainly small save in a few localities, mostly over the Northeastern States, where rather heavy falls occurred on the 9th and 10th and again on the 17th and 18th, some sections, particularly from western Maryland northward, having amounts in excess of any that occurred during the preceding winter. Rather heavy falls occurred also in portions of the upper Lake region, particularly in the upper peninsula and northern portions of the lower peninsula of Michigan where highways were badly blocked, a few localities being entirely isolated for more than a week near the end of the month.

Over many of the interior portions the snowfall was the least of record for March, but over much of Kansas and portions of adjacent States there were heavy falls, ranging up to 10 inches or more, on the 15th and 16th, which, melting slowly, soaked the ground thoroughly and were of great benefit to grains and grasses.

Over the western mountains there were mainly about normal falls, the amounts being generally above normal in most northern and far western mountains. The additional snowfall during March together with the plentiful rainfall over the States from California northward added materially to the outlook for a normal water supply during the coming summer.

RELATIVE HUMIDITY

The percentages of relative humidity, like the total amounts of precipitation, were mainly below normal over the eastern two-thirds of the country, and above normal, as was the case with precipitation, over the more western districts; though in no cases were the departures from normal of importance save the negative values were unusually large in the upper Missouri and Mississippi Valleys, portions of the Plains States, and lower Lake region.

SEVERE LOCAL STORMS, MARCH, 1928

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the annual report of the chief of bureau]

Place	Date	Time	Width of path, yards[1]	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Lone Star, Tex. (near)	3	10 p. m.		1		Tornado	Several farm buildings demolished	Official, U. S. Weather Bureau.
New York State	4					High winds	Roads, buildings, and wire systems damaged throughout the State.	Do.
Tom Green County to Caldwell County, Tex.	9					Heavy hail	Fruit trees, gardens and auto tops damaged; several persons injured. Heaviest damage near Hunter.	Do.
Plant City, Fla	12	8 a. m.				Hail	Much injury to small plants and berry crops	Do.
Georgia	12					Wind, hail, and thunderstorms.	Wires and trees considerably damaged; 1 building unroofed.	Do.
Evansville, Ind., and vicinity.	13					Thunderstorm and hail.	Houses and barns unroofed; signs blown over; windows shattered.	Do.
Meridian, Miss	15	p. m.				Wind and hail	Numerous windows and auto tops pierced; sheds and small houses demolished; garden truck ruined.	Do.
Watley, Ala	15	11:55 p. m.				Small tornado	Considerable property damage; 1 person injured	Do.
Corley, Ala	15				$10,000	do	Two houses completely destroyed; other property damaged; 2 persons injured.	Do
Louisiana (northwest)	15					Thunderstorms and winds.	Damage chiefly to oil-well equipment and telephone and telegraph lines; timber injured; a number of buildings blown down; livestock killed.	Do.
Vicksburg, Miss	15					do	Power and communication lines considerably damages; 1 person injured.	Do.
Sorrento, Fla	17	12:10 a. m.		1	10,000	Tornadic wind	One building demolished; 18 persons injured	Do.
Hays and Caldwell Counties, Tex.	23	P. m.	2,640		275,000	Hail and wind	Heavy crop damage; much destruction in oil fields; path 25 miles long.	Do.
Charles City, Iowa	24					Tornadic wind	Windows broken; small buildings damaged	Do.

[1] "Mi." signifies miles instead of yards.

Severe local storms, March, 1928—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Denver, Colo	25	P. m.			$10,000	Wind	Plate-glass windows, trees, walls and signs damaged; minor damage to homes, wires and automobiles.	Official, U. S. Weather Bureau.
Julesburg, Colo	25	4:30 p. m.			5,000	do	Property of all kinds damaged	Do.
Bonifay, Fla. (north of)	25	8 p. m.	5 mi			Hail	Considerable damage to gardens, early cotton and watermelons.	Do.
Cherokee County, Ga	26	10:30 p. m.		5	15,000	Small tornado	Two residences, a few barns and numerous trees blown down; several persons injured.	Do.
Grand Haven, Mich	26					Rain, wind, and sleet.	Many poles blown down; communication interrupted.	Do.
Ohio	26					Thunder storms	Severe and destructive; character of damage not reported.	Do.
Seattle, Wash., and vicinity.	26			1		Wind	Considerable property damage	Do.
Spring Hill and McMinnville, Tenn.	26					High winds	Several buildings unroofed; warehouse wrecked.	Do.
Spartanburg, Union, and Cherokee Counties, S. C.	26-27				3,000	Severe wind-squalls.	Character of damage not reported	Do.
Sunbeam, Colo	27	1-1:20 a. m.				Winds	Corrals, weather shelter, windmill, and small building damaged.	Do.
Birmingham, Ala. (15 miles north of)	29	6:30 p. m.		4	35,000	Tornado	25 to 50 houses destroyed, also a dozen camp cabins and many outbuildings and other property; 16 persons injured.	Do.
Nashville, Tenn	29		880		2,500	Hail and electrical.	Windows broken and greenhouses damaged; lightning disabled 1,000 telephones.	Do.
Indiana and Ohio (northern halves).	29-20				1,500,000	Glaze	Widespread damage to wire systems, trees and other property.	Do.
Rock Hill, S. C	30	7:30 a. m.	200		6,000	Wind and thunderstorms.	Many buildings unroofed; others damaged; trees uprooted.	Official, U. S. Weather Bureau; observer (Charlotte, N. C.).
Norfolk, Va., and vicinity.	30				25,000	Wind	Large dairy barn collapsed, injuring 2 persons; other minor damage.	Official, U. S. Weather Bureau.

RIVERS AND FLOODS

By H. C. FRANKENFIELD

The only serious flood of the month occurred in the Sacramento River and its tributaries except the upper San Joaquin River. A description of this flood will be found on page 100.

As will be seen from the table following, there were no floods of much consequence apart from those in California, and a moderately high one in the Black Warrior and lower Tombigbee rivers of Alabama. Warnings were issued as required, and the only losses reported were in the Tombigbee and Black Warrior Valleys. These amounted to $21,600, offset by a saving through the warnings of $27,100.

River and station	Flood stage	Above flood stages—dates From—	To—	Crest Stage	Date
ATLANTIC DRAINAGE	Feet			Feet	
Unadilla: New Berlin. N. Y	8			9.2	Mar. 27.
Chenango: Sherburne, N. Y	8	26	27	8.5	Do.
Lynches: Effingham, S. C	14	1	1	14.3	Mar. 1.
Santee:					
Rimini, S. C	12	(1)	5	15.2	Feb. 27.
		14	21	13.0	Mar. 16-17.
Ferguson, S. C	12	(1)	8	13.6	Feb. 28-29.
		15	27	12.7	Mar. 23-25.
Altamaha:					
Charlotte, Ga	15	(1)	1	16.0	Feb. 27.
		12	23	17.4	Mar. 19.
Everett City, Ga	10	22	25	10.0	Mar. 22-25.
Ocmulgee: Abbeville, Ga	11	14	15	11.0	Mar. 14-15.
EAST GULF DRAINAGE					
Tombigbee: Lock No. 4, Demopolis, Ala.	39	13	26	49.6	Mar. 22.
Black Warrior: Lock No. 10, Tuscaloosa, Ala.	46	17	18	50.0	Mar. 17.
West Pearl: Pearl River, La	13	15	18	14.3	Mar. 16.
		22	25	13.4	Mar. 23-24.

[1] Continued from last month.

River and station	Flood stage	Above flood stages—dates From—	To—	Crest Stage	Date
MISSISSIPPI DRAINAGE	Feet			Feet	
Allegheny: Lock No. 5, Freeport, Pa	24	31	(2)	24.3	Mar. 31.
Tuscarawas: Gnadenhutten, Ohio	9	15	15	10.3	Mar. 15.
		31	(2)	11.4	Mar. 31.
Scioto: Larue, Ohio	11	30	30	11.3	Mar. 30.
Tippecanoe: Norway, Ind	6	2	2	6.0	Mar. 2.
		5	6	6.1	Mar. 5-6.
		11	12	6.3	Mar. 12.
		14	14	6.1	Mar. 14.
White, West Fork: Anderson, Ind	12	31	31	12.0	Mar. 31.
Elk: Fayetteville, Tenn	14	9	9	16.2	Mar. 9.
Wisconsin:					
Knowlton, Wis	12	24	27	16.7	Mar. 24.
Wisconsin Rapids, Wis	12	26	26	12.0	Mar. 26.
Big Sioux: Akron, Iowa	12			13.4	Mar. 13.
Illinois:					
Peru, Ill	14	(1)	6	20.0	Dec. 18-19.
		16	24	14.3	Mar. 17-19.
Havana, Ill	14	(1)	3	18.1	Dec. 19.
Beardstown, Ill	14	(1)	6	19.3	Dec. 16-18.
Black: Corning, Ark	11	(1)	2	11.7	Feb. 27-28.
		18	25	11.5	Mar. 20.
Tallahatchie: Swan Lake, Miss	25	16	(2)	29.4	Mar. 25-26.
WEST GULF DRAINAGE					
Trinity: Trinidad, Tex	28	(1)	1	33.8	Feb. 27.
PACIFIC DRAINAGE					
Sacramento:					
Red Bluff, Calif	23	27	27	26.9	Mar. 27.
Hamilton City, Calif	22	28	28	[3] 22.0	Mar. 28.
Knights Landing, Calif	18	26	31	19.2	Mar. 28-30.
Sacramento, Calif	29	26	26	29.5	Mar. 26.
Tuolumne: LaGrange, Calif	8	26	26	8.0	Mar. 26.
Mokelumne: Bensons Ferry, Calif	12	27	29	13.8	Mar. 28.
Willamette:					
Eugene, Oreg	12	12	12	12.5	Mar. 12.
Harrisburg, Oreg	7	11	14	13.1	Mar. 12.
		27	(2)	9.3	Mar. 31.
Willamette, Coast Fork: Saginaw, Oreg.	9	11	11	9.1	Mar. 11.
Santiam: Jefferson, Oreg	10	11	12	13.5	Mar. 12.
		31	31	10.4	Mar. 31.

[1] Continued from last month. [2] Continued at end of month. [3] Estimated.

MEAN LAKE LEVELS DURING MARCH, 1928

By UNITED STATES LAKE SURVEY

[Detroit, Mich., April 3, 1928]

The following data are reported in the "Notice to Mariners" of the above date:

Data	Lakes [1]			
	Superior	Michigan and Huron	Erie	Ontario
Mean level during March, 1928:	*Feet*	*Feet*	*Feet*	*Feet*
Above mean sea level at New York	601.72	578.93	571.50	245.97
Above or below—				
Mean stage of February, 1928	−0.16	+0.15	−0.23	−0.02
Mean stage of March, 1927	+0.42	+0.45	+0.38	+0.26
Average stage for March last 10 years	+0.44	−0.29	+0.16	+0.65
Highest recorded March stage	−0.60	−4.02	−2.35	−1.84
Lowest recorded March stage	+1.53	+1.39	+1.48	+1.83
Average departure (since 1860) of the March level from the February level	−0.10	+0.14	+0.19	+0.26

[1] Lake St. Clair's level: In March, 1928, 573.18 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, MARCH, 1928

By J. B. KINCER

General summary.—During the first decade, aside from some delay by wet soil to field work in the Southeast, particularly in Alabama, Georgia, and South Carolina, the weather, in general, favored outside operations throughout the South, and preparations for spring planting made good advance. Toward the close of the period there was some delay by showers, but in the trans-Mississippi States from Kansas and Missouri southward the weather was ideal for spring work, while the general warmth, light to moderate showers, and abundant sunshine promoted rapid growth. Some cotton was planted in Florida and this work was about half done in the lower Rio Grande Valley of Texas. In the eastern central-valley areas continued wet soil prevented active field work and there were further reports of unfavorable freezing and thawing conditions, particularly in the Ohio Valley section. Showers were helpful in some western sections and mild weather favored livestock interests.

During the second decade, frequent rains and wet soil, followed by unusually cold weather for the season, made a generally unfavorable period for farm operations in Southern States, although the increased soil moisture was favorable in some parts. The cold weather did little or no harm in the Southeast and east Gulf districts, but in the Southwest, particularly in Texas and parts of New Mexico, there was considerable damage to tender vegetation and some harm to fruit bloom. The period was also unfavorable in the Ohio Valley States, where the soil continued mostly too wet to work and freezing and thawing were again detrimental to grains and meadows. In the Great Plains States and the Southwest additional and generous moisture was of benefit and the absence of storms favored livestock. Fruit trees were still beneficially retarded, with bloom of early varieties reported north only to central portions of the east Gulf States and to South Carolina.

During the last decade mostly good advance of seasonal operations was made in Southern States, with especially favorable weather prevailing in the west Gulf area and adjacent sections to the northward. In the Ohio Valley the generally warm weather, with mostly light to moderate precipitation permitted good progress in field operations, although near the close of the month there was further delay by snow or glaze. Farm work and crop growth were stimulated in the Great Plains, with plowing, disking, and seeding active in all parts. The mild weather favored lambing in more western areas and the range benefited from higher temperatures. Rains were useful in California wherever they were sufficiently heavy.

Small grains.—During the first decade the ground continued bare of snow over the principal Wheat Belt, with further complaints of unfavorable freezing and thawing conditions in the east. In the western belt conditions continued more favorable with the crop showing some greening as far north as extreme southern Iowa. In the eastern half of Kansas wheat was mostly very good to excellent, but generally poor to only fair in the west. The condition of the crop was mostly satisfactory in other western areas, but in the Middle Atlantic States the weather was generally unfavorable. During the second decade there was a continuation of unfavorable conditions in the Ohio Valley with further freezing and thawing reported. In the middle Atlantic area considerable additional moisture was received, which was beneficial in some sections, while grains made fairly good advance in the Southeastern States. In the Ohio Valley and lower Lake region conditions were again unfavorable for winter wheat, but in the far Northwest generally favorable weather prevailed.

During the last decade high temperatures and light precipitation stimulated the growth of small grain crops and promoted field work. Progress of wheat in Oklahoma was mostly satisfactory and in Kansas the crop was very good to excellent, except in the extreme northwest. Further winter killing was reported from Ohio Valley States, but winter grains were progressing in more eastern portions and in the far West the weather favored growth and development.

Miscellaneous.—During the first decade pastures made slow growth in the Southeast, while temperature conditions were more favorable in the middle Atlantic area, the Ohio Valley, and the lower Lake region. West of the Mississippi River conditions also improved and mild weather in central-northern portions favored livestock, with much open grazing possible. During the second decade pastures showed some improvement in the Southeast, but continued freezing and thawing made conditions still unfavorable for grass and alfalfa in the Ohio Valley and Lake region. Ranges, alfalfa, and grass were mostly satisfactory in the West and livestock were in good condition generally, with lambing satisfactory and some shearing started in the far Northwest. During the last decade pastures continued improvement in the Southeast and general betterment of the range was noted in most western areas, although there was some local need of moisture. Livestock were good, with the mild weather especially favorable for young lambs and calves.

Planting potatoes became rather general throughout the South during the month with seeding begun as far north as New Jersey at the close. Truck crops made slow growth in southern sections early in the month while cool weather and wet soil retarded planting in the Southeast. Favorable conditions prevailed in the west Gulf area and truck and garden crops made good advance. There was some damage by frost in parts of the west Gulf States during the second decade, but in eastern portions there was little or no injury, although there was some check in growth. The cold weather during the last decade caused practically no damage and at the close of the month truck crops were doing well. Citrus bloom was heavy in Florida and groves were much improved and generally in good condition in California at the close of the month. Deciduous fruits were favorably retarded during most of the month, although toward the close there was a rapid reaction to warm weather, but lower temperatures again had checked development at the close of the period.

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

March was an unusually stormy month over the North Atlantic, especially in the middle section of the steamer lanes where gales were reported on from 6 to 10 days.

The pressure distribution over northern Europe was unusual, as at Lerwick anticyclonic conditions prevailed during the first half of the month while from the 16th to 17th the barometer fell rapidly and comparatively low pressure was maintained until the close of the month. As shown in Table 1, the average pressure for the month was 29.89 inches, while the average for the first 16 days was 30.23 inches and for the last 15 days only 29.53 inches.

Prof. Wm. H. Hobbs, of the University of Michigan, has transmitted to the Weather Bureau a radio message received by him from the observers wintering in the vicinity of the Greenland ice cap, in which it is stated that during the first decade of March abnormally warm weather was experienced at their station. Temperatures of from 20° to 39° were recorded and much melting of snow and ice took place.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, 8 a. m. (75th meridian), North Atlantic Ocean, March, 1928*

Stations	Average pressure	Departure[1]	Highest	Date	Lowest	Date
Belle Isle	29.72	−0.08	30.20	12th	29.14	2d.
Halifax	29.81	−0.09	30.40	7th	29.28	31st.
Nantucket	29.88	−0.12	30.40	7th	29.36	27th.
Hatteras	29.99	−0.04	30.38	6th	29.50	27th.
Key West	30.05	+0.02	30.24	22d	29.78	17th.
New Orleans	30.02	−0.01	30.36	2d	29.70	16th.
Cape Gracias, Honduras	29.93	−0.05	29.98	1st.[2]	29.84	17th.
Turks Island	30.14	+0.12	30.30	2d	30.06	15th.
Bermuda	30.10	+0.07	30.34	8th	29.78	23d.
Horta, Azores	30.00	−0.12	30.38	6th	29.30	15th.
Lerwick, Shetland Islands	29.89	+0.19	30.56	11th	29.18	30th.
Valencia, Ireland	29.68	−0.22	30.13	5th	28.96	30th.
London	29.80	−0.16	30.32	16th	28.96	30th.

[1] From normals shown on H. O. Pilot Chart, based on observations at Greenwich mean noon, or 7 a. m. seventy-fifth meridian.
[2] And on other dates.

The number of days with fog was not far from the normal over the Grand Banks and somewhat above along the American coast north of Hatteras. It was unusually prevalent in the western part of the Gulf of Mexico, being reported on 10 days in the 5° square that includes New Orleans. The eastern section of the steamer lanes was practically clear, as well as the greater portion of the coast of Europe.

During the first three days of the month two well defined depressions were over the ocean, accompanied at times by winds of almost hurricane force. On the 3d the eastern disturbance was central near Madeira and strong northerly gales prevailed over the region between that island and the Azores.

On the 6th northwesterly gales were reported from a limited area in the central section of the steamer lanes but they quickly decreased in intensity, as on the 7th moderate weather was the rule generally.

On the 9th St. Johns, Newfoundland, was near the center of a LOW, with westerly gales in the southerly quadrants.

On the 14th the western LOW of the preceding day, as shown on Chart XI, was central near 40° N., 38° W., and moderate to strong gales were encountered as far south as the thirtieth parallel, where they prevailed until the evening of the 15th.

From the 17th to 20th stormy weather was the rule over the middle and eastern sections of the ocean and on the 17th there was also a well developed LOW over the Gulf of Mexico. The latter moved slowly northeastward along the American coast, accompanied at times by winds of gale force, and on the 22d was central near Belle Isle, although by that time moderate winds only were reported.

On the 22d strong westerly to northwesterly gales were again encountered between the fortieth and fiftieth parallels and the fifteenth and fortieth meridians.

On the 23d and 24th a LOW over Newfoundland was responsible for heavy weather over a limited area southward as far as the Bermudas.

Mr. W. Salmon, third officer, British S. S. *Alvarado*, Capt. F. H. Grant, en route from Puerto Colombia to New York, reports that on the 26th the ship encountered a well defined line squall that reached its greatest intensity at 4 p. m. The noon position of the *Alvarado* was 27° 46′ N., 74° 16′ W. There was also a number of squalls on the afternoon of the 27th; noon position 31° 50′ N., 74° 32′ W. The heaviest of these squalls was accompanied by thunder and lightning, with falling pressure and temperature; maximum force of wind, 5.

The following note was received from the American S. S. *Beaconlight:*

> March 26, 10 a. m., position 29° 31′ N., 77° 52′ W., bearing about 180°, 5 miles distant, after a heavy rain squall, noticed a large waterspout making up, which afterward separated into four small spouts. Wind variable, force 5, passing rain squalls continued for an hour with heavy thunder and lightning.

On the 27th there was a depression central near New York that moved northeastward along the coast and on the 29th was over Newfoundland. On the 28th southwesterly gales were reported near 37° N., 60° W.

From the 29th to 31st westerly to northerly gales occurred between the twentieth meridian and European coast. On the 31st Eastport, Me., was near the center of a LOW and moderate northerly gales were reported by a number of vessels, the storm area extending as far south as Key West.

OCEAN GALES AND STORMS, MARCH, 1928

Vessel	Voyage: From—	Voyage: To—	Position at time of lowest barometer: Latitude	Position at time of lowest barometer: Longitude	Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
NORTH ATLANTIC OCEAN			° ′	° ′				Inches					
Oakwood, Am. S. S.	New Orleans	Bremen	43 51 N.	38 20 W.	Mar. 1	Noon, 1	Mar. 1	29.32	ESE	ENE., 10	NNW	—, 10	E.-ENE.
Stuyvesant, Du. S. S.	Dover	Barbados	40 00 N.	22 35 W.	1	Mdt., 1	3	29.14	WNW	WSW., 10	NNW	NW., 11	—.
West Eldara, Am. S. S.	New York	Antwerp	47 00 N.	25 56 W.	1	Noon, 2	2	29.41	E	NE., 10	NE	NE., 10	NE.-ENE.
Steel Ranger, Am. S. S.	Port Said	Galveston	34 24 N.	16 02 W.	3	2p., 3	4	29.51	WSW	W., 7	N	WSW., 10	S.-SW.-N.
Breedijk, Du. S. S.	New York	Rotterdam	46 25 N.	37 50 W.	2	5a., 3	3	29.81	S	SSW., 10	WNW	SSW., 10	S.-WNW.
China Arrow, Am. S. S.	Colon	New York	35 00 N.	74 00 W.	4	3p., 4	5	30.04	E	E., 4	N	—, 9	E.-S.-NW.
Coahoma County, Am. S. S.	Antwerp	do	47 43 N.	32 58 W.	5	6p., 5	6	29.77	NW	NW., 8	NW	NW., 10	Steady.
Berlin, Ger. S. S.	New York	Cherbourg	47 36 N.	29 04 W.	5	10a., 6	6	29.75	WNW	NNW., 7	NNW	WNW., 11	WNW.-NNW.
Pennsylvania, Dan. S. S.	Nordenham, Ger.	Norfolk	43 00 N.	51 54 W.	8	Noon, 8	9	29.57	S	SSW	WSW	—, 10	S.-W.-WNW.
Samland, Belg. S. S.	Antwerp	New York	45 00 N.	46 05 W.	9	2a., 9	9	29.65	SSE	SW., 8	WSW	SW., 11	SW.-WSW.
Bellepline, Am. S. S.	Rotterdam	do	38 14 N.	60 30 W.	10	3p., 10	11	29.29	SW	W., 11	SE	W., 11	W.-NW.
Wilhelm A. Riedemann, Danz. M. S.	Baytown	Hamburg	37 12 N.	51 45 W.	10	4a., 11	11	29.41	SSW	W., 11	NNW	W., 11	WSW.-WNW.
Raimund, Ger. S. S.	Antwerp	Cuba	44 23 N.	14 46 W.	11	6a., 11	12	29.58	WSW	WSW., 6	NW	—, 10	SW.-SSE.
Munchen, Ger. S. S.	Bremerhaven	New York	47 12 N.	38 05 W.	12	2a., 12	13	28.62	S	S., 10	NW	NW., 12	S.-W.-NW.
Deer Lodge, Am. S. S.	Galveston	Havre	41 19 N.	56 30 W.	13	1p., 13	14	29.49	W	W., 11	N	W., 12	W.-WNW.
Gulfking, Am. S. S.	Port Arthur	Savannah	26 10 N.	86 54 W.	16	6a., 17	17	29.64	W	W., 8	WNW	—, 10	W.-WNW.
Persephone, Danz. M. S.	Colon	Hamburg	39 05 N.	39 00 W.	16	Noon, 17	20	29.71	SW	W., 5	NW	—, 10	—.
Eurana, Am. S. S.	Barrow	Philadelphia	45 28 N.	21 25 W.	21	2p., 21	22	28.96	SE	SW	W	—, 10	SE.-SW.
Cyrus Field, Br. S. S.	Halifax	Cable repairs	45 10 N.	55 25 W.	23	8p., 23	24	29.13	NNE	S., 7	WNW	WNW., 11	S.-W.
Baldbutte, Am. S. S.	Baytown	Hamburg	38 50 N.	59 12 W.	28	Noon, 28	28	29.67	SSW	SSW., 8	SSW	—, 9	Steady.
Sylvan Arrow, Am. S. S.	Providence	Beaumont	24 30 N.	82 50 W.	31	3a., 31	Apr. 1	29.96	WSW	WSW., 5	NNE	NNE., 8	WSW.-NNE.
NORTH PACIFIC OCEAN													
Tenyo Maru, Jap. S. S.	San Francisco	Honolulu	35 30 N.	130 00 W.	Mar. 1	4p., 1	Mar. 2	29.46	E	SSE	WNW	SSE., 8	SSE.-S.
Tokiwa Maru, Jap. S. S.	Yokohama	Victoria	48 50 N.	179 00 E.	1	10p., 3	3	28.96	WNW	SSE., 7	ESE	SSE., 8	—.
Steel Mariner, Am. S. S.	San Pedro	Yokohama	30 13 N.	175 50 W.	2	1a., 2	3	29.39	SSE	SW., 9	NW	WSW., 9	SW.-W.
Tamaha, Br. S. S.	Manila	San Pedro	38 30 N.	156 30 E.	3	10p., 3	3	28.67	S	SW., —	WNW	SW., 9	SW.-WNW.
West Niger, Am. S. S.	Yokohama	Portland	51 05 N.	170 00 W.	2	2p., 3	4	29.63	SE	E., 9	ESE	E., 9	ESE.-E.
Crosskeys, Am. S. S.	Hong Kong	San Francisco	37 50 N.	162 05 E.	4	6a., 4	4	29.03	S	S., 10	W	S., 10	S.-SW.-W.
Paris Maru, Jap. S. S.	Vancouver	Yokohama	42 20 N.	148 45 E.	3	10p., 3	5	28.44	SE	W., 8	NW	NW., 11	—.
Tatsuno Maru, Jap. S. S.	Yokohama	San Francisco	35 27 N.	169 47 W.	3	2p., 5	5	29.15	S	WSW., 9	W	WSW., 9	S.-W.
Pres. Jackson, Am. S. S.	do	Victoria	44 41 N.	162 10 E.	4	2a., 5	5	28.45	ENE	NE., 10	NE	NE., 10	ENE.-NE.
Stockton, Am. S. S.	Cebu	San Francisco	33 04 N.	148 54 E.	6	2a., 6	7	29.06	S	S., 7	NW	NW., 9	S.-SW.
Crosskeys, Am. S. S.	Hong Kong	do	41 09 N.	176 20 E.	7	1p., 7	7	28.99	SSE	S., 9	WSW	S., 9	SSE.-S.-WSW.
Sidney M. Hauptman, Am. S. S.	New York	Los Angeles	10 30 N.	86 50 W.	7	1p., 7	7	29.80	ENE	ENE., 8	ENE	ENE., 8	—.
Bearport, Am. S. S.	Hong Kong	San Francisco	30 14 N.	133 11 E.	10	6a., 10	11	29.43	WSW	W., 9	WNW	W., 9	WSW.-NW.
Steel Mariner, Am. S. S.	San Pedro	Yokohama	30 56 N.	152 42 E.	11	4a., 12	13	29.55	WSW	W., 7	W	WSW., 9	WSW.-W.
West Ison, Am. S. S.	Seattle	Shanghai	49 43 N.	152 44 W.	15	8a., 16	16	28.98	NE	N., 9	NW	N., 9	N.-NNW.
Pres. Garfield, Am. S. S.	Honolulu	Kobe	30 10 N.	179 22 W.	20	4a., 22	23	29.31	SW	SW., 9	N	SW., 10	SW.-NW.
Pres. Jefferson, Am. S. S.	Yokohama	Honolulu	34 24 N.	150 06 E.	23	3p., 24	25	29.19	S	SE., 11	WSW	SE., 11	S.-SE.
Akagisan Maru, Jap. S. S.	do	San Francisco	40 20 N.	154 48 E.	23	6a., 25	26	29.58	NNE	NNW., 10	ENE	NNW., 10	—.
Protesilaus, Br. S. S.	Victoria	Yokohama	45 41 N.	162 04 E.	24	6p., 25	26	29.40	ENE	NNE., 10	NNE	NNE., 11	ENE.-NNE.
Do.	do	do	42 05 N.	152 46 E.	27	10a., 27	27	29.32	SSE	NW., 11	NW	NW., 11	SSE.-NW.
Makaweli, Am. S. S.	Knappton	Kahului	26 14 N.	150 57 W.	25	2p., 25	26	29.85	NE	NE., 9	NE	NNE., 10	NE.-N.
Bearport, Am. S. S.	Hong Kong	San Francisco	47 07 N.	153 50 W.	27	8p., 27	28	29.76	SW	SW., 8	W	SSW., 10	SSW.-SW.
H. M. Storey, Am. S. S.	Balboa	San Pedro	13 13 N.	93 07 W.	31	4p., 31	31	29.74	N	NE., —	ENE	N., 9	N.-NE.
SOUTH PACIFIC OCEAN													
Dewey, Am. S. S.	Dunedin, N. Z.	San Francisco	44 00 S.	175 00 E.	4	3a., 4	9	29.79	NE	NE., 5	NNW	NE., 11	6 pts.

NORTH PACIFIC OCEAN

By WILLIS E. HURD

The Aleutian cyclone lay over the Gulf of Alaska throughout all of March except the first three days. It was strong in development and remarkably little subject to the fluctuations in position usually attending its existence. Therefore, while pressure was considerably below the normal from Kodiak to Juneau, it was slightly to considerably above normal west of the Alaskan peninsula. At St. Paul, Pribilof Islands, there was a rise of more than one-half inch over the average for the preceding February. From the parent cyclone 11 distinct LOWS entered the continent north of the United States during the month, some of these later affecting the weather as far south as the Gulf of Mexico.

The North Pacific anticyclone was fairly stable in development, and occupied a great and unbroken area on several days, though it did not extend as far west on the average as usual, pressure being much below the normal at and in the neighborhood of Midway Island. From the 1st to the 5th, and from the 18th to the 26th, the anticyclone was considerably broken up by cyclones which came into it from the westward, or spread southward upon it from the northern base.

The following table gives pressure data for several island and coast stations in west longitudes:

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level at indicated hours, North Pacific Ocean, March, 1928*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Dutch Harbor [1]	29.76	+0.02	30.32	30th	29.34	12th.
St. Paul [1 2]	29.94	+0.19	30.38	30th	29.12	24th.
Kodiak [1]	29.49	−0.26	30.24	2d [6]	28.70	26th.
Midway Island [1 3]	29.91	−0.17	30.32	24th	29.56	20th.
Honolulu [4]	30.04	0.00	30.21	9th	29.84	24th.
Juneau [4]	29.70	−0.24	30.42	1st	28.91	10th.
Tatoosh Island [4 5]	29.90	−0.08	30.27	14th	29.23	26th.
San Francisco [4 5]	30.06	+0.01	30.33	29th	29.77	26th.
San Diego [4 5]	30.05	+0.03	30.19	7th	29.86	12th.

[1] P. m. observations only.
[2] For 30 days.
[3] For 29 days.
[4] A. m. and p. m. observations.
[5] Corrected to 24-hour mean.
[6] And on other dates.

While gales apparently were not less in number over the ocean as a whole than during any of the four or five preceding months, yet March, 1928, witnessed a decrease in the average of gale force, being the mildest month as regards storm violence since September, 1927. There was comparatively little heavy weather due to the Aleutian cyclone, most of the gales over the eastern part of the ocean arising from the traveling cyclones which entered or impinged upon the high pressure region. The most important of these disturbances was one that appeared west of Midway Island on the 20th, then, moving eastward, lay slightly north of the Hawaiian Islands on the 23d and 24th. Subsequently it went northeastward with increased rapidity to the Washington coast, where it lay on the 27th and caused strong winds to moderate gales. This cyclone was rapidly replaced by strong anticyclonic conditions on a part of its course, which resulted in the production of rather sharp barometric gradients along the western third of the California-Hawaii routes, where moderate gales occurred from the 25th to the 27th, and whole gales during the night of the 25th-26th, near 26° N., 150° W.

Higher wind velocities and much stormier weather generally occurred west than east of the one hundred and eightieth meridian, and gales as high as force 11 were experienced by shipping on the 4th, 24th, 25th, and 27th, as noted in the storm report. These high winds were an accompaniment of cyclones traveling eastward from Asia. Other and lesser gales occurred in these longitudes, distributed among 20 or more days of the month, and covering the whole area north of the 24th parallel.

The winds along the tropical American coast were mostly very light, with frequent calms. Northers were reported in the Gulf of Tehuantepec on the 30th and 31st, and off the coast of Costa Rica on the 7th.

The prevailing wind at Honolulu was from the east. The maximum velocity was 28 m. p. h. from the southwest, during the prevalence of the cyclone of the 24th. It was the third warmest March on record at this place.

A considerable increase in fog since February was observed over several parts of the ocean, particularly along the northern routes and over the eastern part of the ocean north of the thirtieth parallel, between longitude 160° W. and the coast. Along and near the coast proper fog was most frequent, with a maximum of occurrence between San Francisco and San Diego, where the percentage was considerably above the normal of 15 to 20 per cent. In east longitudes fog was beginning to appear again, after being practically absent since November. It was reported on the China coast during the early days of the month.

CLIMATOLOGICAL TABLES[1]

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings:

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, March, 1928

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	56.2	+0.1	Selma	89	30	Valley Head	22	1	6.28	+0.53	Alaga	9.71	Pushmataha	2.92
Arizona	55.4	+2.9	Quartzite	96	21	Alpine	−1	15	0.20	−0.93	Bright Angel	1.80	31 stations	0.00
Arkansas	52.7	0.0	Helena	92	29	3 stations	20	[2] 2	2.53	−2.21	Lambrook	6.91	Mountain Home	0.73
California	54.1	+2.5	Angiola	102	19	Helm Creek	−12	28	5.38	+1.58	Deer Creek	24.14	3 stations	0.00
Colorado	36.9	+2.1	Lamar	85	23	Dillon	−26	16	1.61	+0.35	Savage Basin	5.25	Blanca	0.09
Florida	66.7	+1.0	Hypoluxo	95	26	Garniers	31	18	4.31	+1.37	Apalachicola	13.07	Key West	0.34
Georgia	56.7	0.0	2 stations	90	29	2 stations	18	19	6.42	+1.73	Thomasville	9.67	Double Branches	3.45
Idaho	38.4	+2.6	3 stations	81	[2] 20	do	−27	2	2.67	+1.20	Roland	8.96	Mud Lake	0.13
Illinois	42.8	+2.2	Carbondale	86	22	Waukegan	5	5	1.54	−1.67	Newton	3.58	Astoria	0.45
Indiana	39.6	−1.1	4 stations	83	23	Mauzy	6	17	1.81	−2.05	Terre Haute	4.55	Rochester	0.19
Iowa	38.9	+4.3	2 stations	88	23	Lake Park	1	5	1.44	−0.32	Davenport (No. 2)	2.75	Oakland	0.36
Kansas	46.7	+2.9	3 stations	89	[2] 22	3 stations	6	[2] 16	1.41	−0.07	Newton	3.18	Olathe	0.26
Kentucky	45.6	−0.8	do	85	[2] 23	Shelbyville	12	[2] 1	2.64	−2.20	Middleboro	5.40	Scott	0.99
Louisiana	62.4	+1.7	Schriever	92	11	Amite	29	18	4.30	−0.28	Logansport	9.34	Delta Farms	1.85
Maryland-Delaware	41.8	−0.8	2 stations	83	24	Oakland, Md	7	6	2.95	−0.71	Frostburg, Md	4.90	Great Falls, Md	1.82
Michigan	28.8	−0.9	Bangor	80	25	Humboldt	−30	6	1.95	−0.27	Bay City	5.70	Twin Falls	0.60
Minnesota	28.2	+2.4	Gull Lake Dam	87	25	Itasca State Park	−23	5	0.82	−0.32	Fosston	2.80	Alexandria	T.
Mississippi	57.7	+0.6	2 stations	90	26	University	23	18	5.29	−0.51	Columbia	7.50	Hernando	1.50
Missouri	46.3	+2.5	do	89	[2] 22	Unionville	10	5	1.54	−1.46	Bolivar	3.56	Lamonte	0.11
Montana	35.6	+5.4	Sun River Canyon	82	20	Hebgen Dam	−23	1	0.75	−0.16	Heron	6.18	Crow Agency	0.00
Nebraska	40.8	+5.2	4 stations	90	[2] 22	Mitchell (near)	−12	1	0.96	−0.14	Curtis	2.61	Mitchell (near)	0.28
Nevada	45.5	+4.0	Logandale	89	26	Rye Patch	7	15	1.36	+0.56	Carson City	4.46	Searchlight	0.00
New England	30.8	−1.4	2 stations	73	[2] 25	2 stations	−23	[2] 4	2.36	−0.87	Plymouth, Mass	4.41	Milo, Me	1.11
New Jersey	38.3	−0.4	Vineland	82	25	Layton	6	11	2.84	−1.08	Chatham	3.82	Phillipsburg	1.70
New Mexico	45.8	+2.4	3 stations	92	27	2 stations	−15	16	0.38	−0.45	Red River Canyon	2.94	26 stations	0.00
New York	31.1	−0.9	Dansville	77	24	Stillwater Reservoir	−19	6	3.00	−0.06	North Lake	5.95	Lauterbrunnen	1.02
North Carolina	50.0	−0.2	Hot Springs	86	29	Mount Mitchell	4	2	3.46	−0.82	Rock House (No. 1)	7.87	Southport	1.25
North Dakota	28.1	+5.5	Edgeley	85	24	2 stations	−17	7	0.54	−0.29	Cando	2.60	2 stations	0.00
Ohio	38.1	−1.4	2 stations	82	26	Medina	4	6	2.84	−0.64	Cadiz	4.70	Wilmington	0.98
Oklahoma	52.2	+2.2	Waurika	97	28	Boise City	12	16	1.65	−0.58	Watts	3.38	Altus	0.35
Oregon	45.4	+3.2	2 stations	83	18	Ukiah	6	2	5.41	+2.38	Valsetz	27.92	Prineville	0.58
Pennsylvania	37.0	−0.5	Newell	82	13	Brookville	−3	5	3.24	−0.30	Elk Lick	5.45	Ansonia	1.65
South Carolina	53.9	−0.9	2 stations	88	29	Walhalla	10	10	3.87	−0.03	Beaufort (near)	6.76	Rimini	1.20
South Dakota	36.6	+5.4	Vermillion	90	23	Cottonwood	−2	30	0.77	−0.30	Wagner	2.94	Mellette	T.
Tennessee	49.2	−0.2	Clarksville	87	26	Crossville	9	19	4.65	−0.65	Copperhill	8.52	Newbern	1.53
Texas	61.0	+2.3	Eagle Pass	106	28	2 stations	11	[2] 16	1.16	−0.90	Anderson	6.38	9 stations	0.00
Utah	42.4	+4.2	Saint George	85	21	Laketown	−10	1	1.74	+0.20	Silver Lake	5.58	Myton	T.
Virginia	45.6	−0.4	Charlottesville	87	24	Ashland	10	6	2.74	−1.02	Speers Ferry	5.03	Roanoke	1.46
Washington	43.3	+2.6	Centralia	85	19	Bumping Lake	−3	1	6.29	+2.52	Heather Meadows	28.98	Wenatchee	0.32
West Virginia	41.4	−1.7	Williamson	86	29	Bayard	−3	4	3.87	+0.01	Bayard	7.64	Upper Tract	1.32
Wisconsin	29.5	+0.4	Meadow Valley	82	25	Rest Lake	−33	6	1.49	−0.26	Racine	3.74	Amery	0.23
Wyoming	32.7	+2.8	Fort Laramie (near)	79	22	2 stations	−37	2	0.86	−0.13	Dome Lake	4.19	2 stations	0.00
Hawaii	70.7	+2.0	Mahukona	91	30	Volcano Observatory	47	26	4.23	−4.64	Olokele (Mauka)	18.60	Waiawa	0.00
Porto Rico	74.1	+0.3	Comerio Falls	98	7	2 stations	52	26	2.08	−1.46	Adjuntas	5.39	2 stations	0.60

LATE REPORTS, FEBRUARY, 1928

Alaska	17.3	+9.0	Bonanza Mine	58	[2] 23	Allakaket	−46	11	2.66	+0.10	Latouche	24.20	Fort Yukon	0.29
New York	24.4	+2.5	2 stations	60	[2] 8	Gabriels	−32	26	2.67	−0.11	High Market	5.00	Lauterbrunnen	0.88

[1] For description of tables and charts see REVIEW, January, 1928, p. 43.

[2] Other date also.

TABLE 1.—*Climatological data for Weather Bureau Stations, March, 1928*

District and station	Elevation of instruments: Barometer above sea level	Thermometer above ground	Anemometer above ground	Pressure: Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Departure from normal	Days with .01, or more	Wind (3-cup anemometer used): Total movement	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0–10	In.	In.
New England							33.1	+0.4										71	2.54	−1.0										5.4		
Eastport	76	67	85	29.70	29.78	−0.15	29.7	+0.8	48	27	36	7	9	23	27	27	22	72	2.47	−1.4	21	8,282	w.	43	e.	18	8	9	14	6.5	12.4	1.0
Greenville, Me	1,070	6		28.59	29.70		23.6		52	26	33	−7	4	14	38				2.55		10	6,713	nw.	27		27	11	7	13		15.9	
Portland, Me	103	82	117	29.72	29.85	−.11	32.0	+0.2	52	24	39	11	7	25	23	28	20	65	2.79	−1.1	14	6,433	nw.	33	sw.	4	13	6	12	5.4	11.1	T.
Concord	289	70	79	29.52	29.84	−.16	31.2	+0.4	69	24	40	−1	4	22	44				1.56	−1.5	10	4,873	w.	22	w.	28	16	8	7	4.0	10.4	0.0
Burlington	403	11	48	29.38	29.84	−.16	27.6	−1.5	64	26	35	3	11	20	34				2.23	+0.2	14	7,615	n.	40	sw.	4	6	7	18	7.2	25.9	0.2
Northfield	876	12	60	28.87	29.85	−.15	25.2	−1.2	65	24	35	−5	11	16	52	23	20	80	2.14	−0.6	17	5,030	s.	33	se.	4	7	7	17	6.9	24.4	1.5
Boston	125	115	188	29.71	29.85	−.12	37.0	+1.4	70	24	45	17	4	29	36	32	25	64	1.56	−2.0	9	7,822	w.	28	sw.	28	8	14	9	5.3	6.5	0.0
Nantucket	12	14	90	29.84	29.85	−.13	36.2	+0.7	55	27	42	19	4	30	26	33	29	77	3.22	−0.8	11	11,894	w.	43	sw.	18	11	9	11	5.2	9.1	0.0
Block Island	26	11	46	29.83	29.86	−.12	36.6	+1.2	53	14	42	20	6	32	21	33	29	75	3.21	−0.6	9	14,266	w.	48	ne.	18	13	8	10	5.0	5.4	0.0
Providence	160	215	251	29.69	29.87	−.11	36.2	+0.5	64	24	44	15	6	28	31	31	23	62	2.64	−0.8	11	9,029	nw.	46	nw.	31	13	7	11	4.8	9.7	0.0
Hartford	159	122		29.70	29.88	−.11	36.0	+1.0	68	25	43	15	4	28	33				3.11	−0.8	10		nw.				14	7	10	4.7	7.9	0.0
New Haven	106	74	153	29.78	29.90	−.09	36.7	+0.9	65	24	44	16	6	30	30	32	27	71	2.98	−1.2	10	6,665	w.	31	ne.	18	12	11	8	4.8	8.0	0.0
Middle Atlantic States							41.1	+0.5										68	2.52	−0.9										5.5		
Albany	97	102	115	29.78	29.89	−.12	33.6	+0.9	68	26	41	9	11	26	35	29	24	70	2.26	−0.4	8	5,333	nw.	36	s.	4	11	13	7	5.0	16.0	0.0
Binghamton	871	10	84	28.93	29.88	−.14	32.6	0.0	71	26	41	9	11	24	39				2.79	+0.2	12	5,440	w.	26	w.	27	2	11	18	7.5	24.1	0.0
New York	314	414	454	29.57	29.92	−.08	38.3	+0.6	69	25	45	17	6	31	29	33	25	59	2.54	−1.1	11	12,970	nw.	53	nw.	31	7	14	10	5.6	4.5	0.0
Harrisburg	374	94	104	29.54	29.95	−.08	39.2	+0.3	75	26	47	20	5	32	33	34	27	66	3.56	+0.4	9	5,652	nw.	26	s.	4	6	11	14	6.0	21.6	0.0
Philadelphia	114	123	341	29.81	29.94	−.08	42.0	+1.2	75	26	50	22	6	34	33	37	30	67	2.10	−1.3	8	8,315	nw.	42	ne.	18	7	14	10	5.5	2.8	0.0
Reading	325	81	98	29.57	29.93		39.8		76	26	48	20	6	32	37	35	29	70	2.92	−0.6	10	5,689	nw.	27	nw.	27	15	8	8	4.8	10.5	0.0
Scranton	805	111	119	29.03	29.92	−.10	34.8	−0.9	72	26	43	13	5	27	38	31	26	72	2.05	−1.1	10	6,009	w.	29	sw.	27	6	12	13	6.5	10.3	0.0
Atlantic City	52	37	172	29.87	29.93	−.09	40.0	+1.4	60	25	46	20	6	34	22	36	32	75	2.48	−1.1	10	12,633	w.	58	ne.	18	12	11	8	4.8	0.2	0.0
Cape May	17	13	49				40.9	+0.1	65	25	48	19	4	34	24	37	33	78	2.22		12		nw.				13	8	10		T.	0.0
Sandy Hook	22	10	55	29.88	29.90		38.3		68	25	44	20	6	32	29	33	28	60	2.44		11	11,777	nw.	44	w.	27	9	11	11	5.4	1.5	0.0
Trenton	190	159	183	29.71	29.92		39.1		77	26	47	18	6	31	35	34	29	70	2.19	−1.8	10	8,458	nw.	40	nw.	27	9	11	11	5.7	4.1	0.0
Baltimore	123	100	215	29.81	29.94	−.09	43.8	+1.5	75	25	52	23	6	36	31	37	30	65	3.12	−0.6	8	8,125	sw.	44	w.	30	11	10	10	5.5	1.7	0.0
Washington	112	62	85	29.82	29.94	−.10	44.1	+1.5	80	24	53	23	6	36	41	37	30	64	2.17	−1.6	8	5,791	nw.	32	nw.	30	10	11	10	5.4	0.5	0.0
Cape Henry	18	8	54	29.92	29.94		48.0		86	30	56	31	19	40	38	42	37	60	2.65	−1.2	8	8,825	sw.	37	e.	18	10	14	7	5.4	0.0	0.0
Lynchburg	681	153	188	29.20	29.95	−.10	47.5	+0.2	81	29	59	23	6	36	46	39	31	59	1.93	−1.6	8	6,103	w.	37	sw.	30	13	14	4	4.2	2.2	0.0
Norfolk	91	170	205	29.86	29.96	−.07	48.6	+0.4	82	30	58	30	19	40	35	42	36	66	2.73	−1.0	6	9,684	ne.	46	sw.	30	8	12	11	5.6	0.0	0.0
Richmond	144	11	52	29.81	29.97	−.07	47.4	+0.2	81	30	58	24	6	36	38	39	32	64	2.71	−1.0	7	6,729	sw.	44	w.	30	15	9	7	4.5	T.	0.0
Wytheville	2,304	49	55	27.55	29.97	−.08	42.4	+0.1	78	29	52	19	6	32	41	35	29	67	2.15	−1.3	12	5,437	w.	37	w.	30	9	13	9	5.3	6.9	0.0
South Atlantic States							54.5	+0.8										71	3.60	−0.1										5.2		
Asheville	2,253	70	84	27.59	29.98	−.08	45.8	+0.9	79	29	56	23	19	36	40	39	34	69	3.95	0.0	15	6,970	nw.	31	nw.	27	13	10	8	4.5	1.1	0.0
Charlotte	779	55	62	29.14	29.98	−.07	50.9	+0.5	81	23	61	28	19	41	39	43	37	65	3.53	−0.6	16	4,210	sw.	28	sw.	30	12	10	9	5.1	T.	0.0
Hatteras	11	11	50	29.95	29.96	−.08	53.4	+1.4	72	29	60	36	19	46	21	49	45	75	2.26	−2.0	11	10,336	ne.	37	nw.	31	14	10	7	4.5	0.0	0.0
Raleigh	376	103	110	29.57	29.98	−.07	49.9	−0.3	79	30	60	29	6	40	34	44	38	70	2.58	−1.7	8	6,004	nw.	35	sw.	30	12	8	11	5.4	0.0	0.0
Wilmington	78	81	91	29.91	30.00	−.05	54.0	+0.7	78	30	63	32	19	45	28	49	46	80	1.84	−1.3	14	5,155	w.	26	sw.	30	9	10	12	5.6	0.0	0.0
Charleston	48	11	92	29.95	30.00	−.06	57.4	0.0	77	26	64	40	19	50	23	51	47	73	3.08	+0.1	11	6,915	sw.	27	e.	17	10	11	10	5.3	0.0	0.0
Columbia, S. C	351	41	57	29.61	30.00	−.06	55.4	+0.2	85	23	65	32	19	46	38	48	41	66	2.90	−0.8	11	5,235	sw.	35	sw.	30	11	8	12	5.6	0.0	0.0
Due West	711	10	55	29.23	30.02		52.4		83	29	63	26	19	42	41				4.15		14	6,755	w.	36	w.	30	11	10	10	5.3	0.0	0.0
Greenville, S. C	1,039	130	146	28.88	29.98		51.7	+1.8	81	23	61	27	19	42	38	44	39	70	4.24		14	5,953	ne.	34	sw.	30	9	9	13	5.5	T.	0.0
Augusta	182	62	77	29.80	29.99	−.07	57.4	+1.4	87	29	67	33	19	48	38	50	44	68	4.35	+0.2	12	4,524	nw.	30	sw.	30	9	13	9	5.5	0.0	0.0
Savannah	65	150	194	29.94	30.01	−.05	59.6	+0.6	84	23	68	40	3	51	30	53	48	74	7.16	+4.1	14	7,934	w.	50	w.	30	8	13	10	5.7	0.0	0.0
Jacksonville	43	209	245	29.98	30.03	−.03	63.8	+1.2	87	29	73	42	18	54	28	55	50	70	4.38	+1.5	11	8,180	sw.	40	w.	30	10	14	7	4.9	0.0	0.0
Florida Peninsula							71.1	+1.3										76	1.15	−1.1										2.6		
Key West	22	10	64	30.01	30.04	−.01	74.2	+1.6	85	30	80	55	23	69	19	67	64	77	0.34	−1.0	4	6,646	se.	34	w.	17	21	9	1	2.4	0.0	0.0
Miami	25	71	164	30.03	30.06		71.0	+0.8	83	27	78	46	22	64	24	66	62	76	0.45	−2.2	5	7,523	s.	33	s.	17	16	10	5	3.8	0.0	0.0
Tampa	35	79	87	30.01	30.05	−.02	68.2	+1.4	86	15	77	47	1	60	24	60	57	76	2.67	−0.1	5	4,300	sw.	20	sw.	16	14	8	9	4.6	0.0	0.0
Titusville	44	5		29.99	30.04		67.0		91	30	79	40	19	55	39				6.68		9		sw.				14	14	3	3.8	0.0	0.0
East Gulf States							58.1	+0.6										72	5.92	+0.5										5.9		
Atlanta	1,173	190	216	28.76	30.01	−.05	51.8	−0.2	83	29	61	28	19	43	34	45	38	66	5.69	+0.4	13	8,289	nw.	35	nw.	30	11	7	13	5.4	T.	0.0
Macon	370	78	87	29.61	30.01	−.05	56.4	−0.3	85	29	67	31	3	46	30	49	44	71	5.21	−0.3	15	4,614	nw.	24	sw.	30	13	3	15	5.5	0.0	0.0
Thomasville	273	49	58	29.72	30.02	−.04	62.0	+1.8	84	29	72	38	18	52	31	55	50	74	9.77	+4.7	13	3,524	sw.	22	sw.	30	8	9	14	6.4	0.0	0.0
Apalachicola	36	42	49	29.98	30.02		61.8		77	26	68	40	18	56	22	58	55	81	13.97		9	5,469	s.	34	s.	12	10	9	12	5.6	0.0	0.0
Pensacola	56	149	185	29.96	30.02	−.04	61.2	+0.9	76	26	67	37	18	56	21	56	53	79	4.18	−0.6	11	8,628	n.	32	se.	16	6	14	11	6.2	0.0	0.0
Anniston	741	9	57	29.23	30.04	−.02	52.9	+0.4	86	29	64	28	19	42	41				6.75	+1.0	15	4,240	nw.	22	w.	30	13	9	9	5.1	T.	0.0
Birmingham	700	11	48	29.25	30.02	−.04	54.0	−1.4	85	29	64	29	18	44	30	47	42	68	7.71	+2.0	16	5,171	n.	25	s.	29	10	7	14	5.8	T.	0.0
Mobile	57	125	161	29.94	30.00	−.06	62.0	+2.3	80	9	70	36	18	54	27	50	52	77	5.47	−0.5	13	6,923	s.	31	n.	27	5	10	16	6.4	0.0	0.0
Montgomery	223	100	112	29.76	30.02	−.04	57.9	+0.1	85	29	67	33	18	49	32	51	45	67	5.22	−0.8	14	4,907	n.	23	sw.	29	7	9	15	6.5	0.0	0.0
Corinth	469	6					53.0		82	26	63	28	18	42	39				5.54		11		s.				4	21	6		T.	0.0
Meridian	375	87	95	29.61	30.01	−.04	57.0	−0.1	87	29	67	31	18	47	37	50	44	60	6.18	+0.6	13	4,571	ne.	27	se.	15	7	9	15	6.4	0.0	0.0
Vicksburg	247	65	73	29.74	30.02	−.02	58.8	+0.3	85	26	68	35	17	50	31	51	45	68	3.52	−2.0	9	5,463	s.	35	nw.	15	7	12	12	6.0	0.0	0.0
New Orleans	53	76	84	29.95	30.00	−.04	65.1	+2.8	86	13	73	41	18	57	25	59	55	76	5.42	+0.7	7	4,760	sw.	20	n.	24	7	12	12	6.0	0.0	0.0
West Gulf States							60.9	+1.7										71	1.36	−1.4										5.1		
Shreveport	249	77	93	29.72	29.99	−.03	59.2	+0.9	89	25	69	38	19	50	31	51	45	68	4.08	0.0	9	4,859	s.	27	nw.	15	13	10	8	5.0	0.0	0.0
Bentonville	1,303	11	44				49.0	+1.7	79	28	60	23	5	38	36				2.63		6		s.		nw.		17	5	9		1.6	0.0
Fort Smith	457	79	94	29.49	29.97	−.04	53.1	+0.5	83	12	63	33	5	43	36	45	38	63	1.34	−1.7	7	6,146	e.	33	e.	15	10	10	11	5.6	T.	0.0
Little Rock	357	136	144	29.61	29.99	−.04	53.9	+0.9	82	28	63	34	5	44	34	46	39	62	1.70	−3.2	4	6,452	n.	33	n.	26	9	10	12	5.6	0.0	0.0
Austin	605	136	148	29.34	29.97		63.7	+3.0	94	25	76	35	20	52	41				0.29	−2.0	5	6,631	n.	34	n.	16	15	4	12	4.5	T.	0.0
Brownsville	57	53	61	29.86	29.92		71.6	+3.4	102	26	80	39	18	63	33	64	61	79	0.16	−1.1	2	6,022	s.	27	n.	16	10	12	9	4.9	0.0	0.0
Corpus Christi	20	11	78	29.93	29.95	−.03	67.2	+2.2	95	24	75	38	17	60	29	62	59	83	1.08	−0.8	8	8,631	se.	31	nw.	16	10	8	13	5.6	0.0	0.0
Dallas	512	220	237	29.42	29.97		59.1		91	25	69	33	17	49	33				0.99		4	10,051	ne.	46	nw.	15	13	9	9	4.7	0.0	0.0
Fort Worth	670	106	114	29.24	29.96	−.02	59.9	+2.2	92	25	71	36	17	49	35	51	44	63	1.10	−1.1	3	6,968	nw.	38	s.	28	11	10	10	5.2	0.0	0.0
Galveston	54	106	114	29.94	30.00	−.01	62.7	+0.3	80	29	68	41	17	57	23	58	56	80	0.70	−2.0	8	7,655	s.	36	s.	10	6	14	11	6.1	0.0	0.0
Groesbeck	461	11	56	29.48	29.96		59.9		92	25	71	34	17	49	30				0.80		6	8,195	s.	35	ne.	26	15	6	10	4.9	T.	0.0
Houston	138	292	314	29.84	29.99		64.2	+0.9	94	26	73	38	17	55	32				1.35	−2.1	9	8,612	s.	35	n.	16	12	8	11	5.2	0.0	0.0
Palestine	510	64	72	29.44	29.98	−.02	59.2	+0.1	90	25	69	36	17	50	32	53	48	72	1.92	−1.6	9	5,945	s.	25	s.	28	15	8	10	4.9	T.	0.0
Port Arthur	34	58	66	29.94	29.98		62.9		81	13	70	41	17	56	25				2.26		9	6,270	s.	23	sw.	25	10	7	14	6.1	0.0	0.0
San Antonio	693	119	132	29.23	29.95	−.03	65.6	+2.8	95	25	77	33	17	54	37	55	47	60	2.34	+0.5	4	5,271	ne.	27	n.	29	15	6	10	4.6	T.	0.0
Taylor	583	55	63	29.38	29.99	.00	62.7	+3.0	95	25	75	33	17	50	41				0.30	−2.3	4	6,734	s.	27	s.	28	14	9	8	4.5	T.	0.0

TABLE 1.—*Climatological data for Weather Bureau Stations, March, 1928*—Continued

District and station	Elevation of instruments			Pressure			Temperature of the air												Precipitation			Wind (3-cup anemometer used)										
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Total	Departure from normal	Days with .01, or more	Total movement	Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*		*°F.*	*°F.*		*°F.*	*°F.*	*°F.*	*°F.*	*%*	*In.*	*In.*		*Miles*								*0-10*	*In.*	*In.*
Ohio Valley and Tennessee							**43.3**	**−0.9**										**69**	**3.04**	**−1.3**										**6.2**		
Chattanooga	762	189	213	29.19	30.01	−0.05	50.6	−0.6	86	29	60	26	19	41	41	43	36	62	5.24	−0.5	15	6,176	sw.	42	nw.	26	8	10	13	5.9	0.5	0.0
Knoxville	995	102	111	28.94	30.00	−.06	48.8	+0.1	83	29	59	28	18	39	41	42	36	67	4.79	−0.3	14	4,930	sw.	36	sw.	29	8	10	13	5.7	2.4	0.0
Memphis	399	76	97	29.58	30.01	−.05	51.8	−0.5	78	28	60	29	5	43	35	46	40	70	3.14	−2.1	8	5,632	n.	32	w.	15	10	9	12	5.6	0.2	0.0
Nashville	546	168	191	29.44	30.04	−.01	48.8	−0.4	81	29	58	27	19	40	37	42	36	66	3.26	−1.8	12	7,005	w.	42	nw.	26	11	8	12	5.5	1.0	0.0
Lexington	989	193	230	28.92	30.01	−.04	42.1	−1.6	77	23	52	18	15	33	41	----	----	----	2.67	−2.0	12	9,549	sw.	42	nw.	26	10	7	14	6.2	5.1	0.0
Louisville	525	188	234	29.43	30.02	−.03	44.0	−1.4	79	23	53	21	5	35	38	38	32	69	2.66	−1.7	8	7,848	s.	45	nw.	26	6	13	12	6.0	1.6	0.0
Evansville	431	76	116	29.56	30.03	−.01	45.0	−0.9	79	23	54	24	5	36	37	39	34	68	1.04	−3.2	8	6,664	s.	37	nw.	26	5	15	11	5.9	5.0	0.0
Indianapolis	822	194	230	29.09	29.99	−.05	39.2	−0.8	77	23	48	16	5	31	41	34	28	66	2.44	−1.5	9	8,928	nw.	47	w.	26	9	11	11	5.6	0.6	0.0
Royal Center	736	11	55	29.15	29.97	------	36.3	------	76	23	45	14	5	28	43	----	----	----	0.86	------	7	8,659	w.	42	nw.	26	6	13	12	6.7	0.8	0.0
Terre Haute	575	96	129	29.36	29.99	------	41.8	------	80	23	51	19	5	33	38	36	30	69	4.55	------	9	7,087	nw.	36	nw.	26	7	13	11	6.1	0.5	0.0
Cincinnati	627	11	51	29.31	30.00	−.05	40.6	−0.3	75	23	50	17	5	31	37	35	30	71	1.31	−2.6	9	6,406	sw.	33	w.	26	9	8	14	6.3	0.9	0.0
Columbus	822	179	222	29.08	29.98	−.06	38.2	−0.9	72	24	46	16	5	30	41	34	28	70	2.79	−0.7	12	8,266	nw.	50	nw.	26	9	11	11	5.9	1.8	0.0
Dayton	899	137	173	29.00	29.98	------	39.1	−1.4	72	23	48	18	5	31	42	34	29	70	2.04	−1.6	8	7,466	nw.	41	w.	26	5	12	14	7.0	1.9	0.0
Elkins	1,947	59	67	27.88	29.99	−.05	38.1	−1.9	75	26	49	4	4	27	45	32	28	74	3.33	−0.7	17	5,039	w.	28	w.	27	2	12	17	7.3	28.6	0.0
Parkersburg	637	77	82	29.33	30.00	−.05	41.6	−1.2	78	26	52	18	6	32	36	35	30	72	3.54	−0.3	13	4,980	sw.	30	nw.	26	6	8	17	6.9	8.1	0.0
Pittsburgh	842	353	410	29.03	29.95	−.09	38.6	−1.0	75	13	46	15	5	31	29	33	27	69	4.25	+1.2	15	8,690	w.	40	w.	27	5	11	15	6.7	9.4	0.0
Lower Lake Region							**32.8**	**−0.3**										**74**	**2.59**	**−0.1**										**6.6**		
Buffalo	767	247	280	29.05	29.90	−.12	30.3	−0.8	67	26	37	10	3	24	39	28	25	82	1.76	−0.8	18	13,872	w.	68	sw.	27	5	8	18	7.3	13.8	0.5
Canton	448	10	61	29.35	29.85	------	26.0	−1.7	63	26	34	−1	6	18	38	----	----	----	3.00	+0.2	17	7,690	w.	40	sw.	4	11	6	14	5.7	20.8	0.8
Oswego	335	76	91	------	29.84	−.17	30.6	−0.6	68	24	37	10	11	24	39	----	----	80	2.52	−0.4	22	------	nw.	31	sw.	27	4	4	23	----	33.0	0.0
Rochester	523	86	102	29.31	29.90	−.12	32.1	+0.3	72	24	39	12	3	25	36	27	22	72	3.55	+0.8	22	7,822	w.	40	sw.	27	2	9	20	7.5	30.1	T.
Syracuse	597	97	113	29.23	29.89	−.13	31.6	+0.2	73	24	38	12	6	25	39	----	----	----	3.84	+1.5	20	9,394	w.	45	w.	27	1	10	20	7.8	32.0	0.5
Erie	714	130	166	29.14	29.93	−.09	33.0	−0.5	75	24	40	12	5	26	35	29	24	71	2.16	−0.5	12	10,543	sw.	46	sw.	27	7	14	10	6.1	6.8	0.0
Cleveland	762	190	201	29.10	29.94	−.09	35.4	+0.8	74	24	42	16	5	28	37	32	27	74	2.08	−0.6	11	8,540	w.	36	w.	27	7	10	14	6.3	2.2	T.
Sandusky	629	5	67	29.24	29.94	−.09	36.1	+1.0	76	24	44	14	6	28	44	----	----	----	2.63	−0.1	11	7,405	w.	32	sw.	26	5	13	13	6.5	1.9	0.0
Toledo	628	208	243	29.26	29.96	−.07	35.4	+0.1	73	24	44	15	6	27	42	31	25	67	2.33	−0.2	12	10,123	w.	44	sw.	26	12	5	14	5.6	2.5	T.
Fort Wayne	856	113	124	29.02	29.96	------	36.4	−2.5	71	23	45	17	5	28	41	32	28	74	1.47	------	10	7,396	w.	35	w.	26	7	7	17	6.7	2.3	0.0
Detroit	730	218	258	29.13	29.94	−.11	33.7	+0.3	72	24	42	11	3	26	38	29	24	71	1.99	−0.4	11	8,135	nw.	41	sw.	4	7	10	14	6.5	9.6	0.8
Upper Lake Region							**28.8**	**+0.6**										**76**	**1.91**	**−0.3**										**5.5**		
Alpena	609	13	92	29.23	29.92	−.00	25.4	−0.1	57	24	34	−2	3	17	31	23	19	78	2.12	+0.1	12	9,109	nw.	40	nw.	4	12	13	6	4.9	21.2	T.
Escanaba	612	54	60	29.26	29.95	−.09	25.0	+0.8	57	24	34	−10	6	16	37	21	18	78	2.34	+0.4	10	6,847	n.	44	n.	26	12	10	9	4.9	13.4	T.
Grand Haven	632	54	89	29.25	29.95	−.08	32.1	+0.4	67	23	40	13	5	24	37	29	25	77	1.50	−0.8	11	8,945	w.	37	w.	1	7	14	10	6.0	5.7	0.0
Grand Rapids	707	70	87	29.17	29.96	−.07	33.4	0.0	71	24	41	13	5	26	37	29	25	68	2.04	−0.4	10	5,115	nw.	25	nw.	2	5	13	13	6.6	11.2	T.
Houghton	668	64	90	29.20	29.95	−.09	24.0	+1.2	64	23	32	−8	6	16	32	----	----	----	1.49	−0.6	14	7,617	w.	37	w.	4	8	12	11	5.9	12.0	T.
Lansing	878	6	49	28.97	29.94	------	30.5	−1.7	73	24	39	9	3	22	33	28	26	87	2.43	+0.1	13	5,215	nw.	24	nw.	4	11	9	11	5.5	13.3	2.8
Ludington	637	60	66	29.22	29.94	------	30.8	------	64	23	37	11	5	24	33	28	24	77	1.99	------	10	8,221	n.	37	sw.	4	10	10	11	5.4	10.9	T.
Marquette	734	77	111	29.12	29.95	−.00	26.5	+1.7	58	25	34	−1	5	19	32	23	19	79	1.67	−0.6	13	7,204	nw.	33	sw.	23	6	10	15	6.5	12.4	T.
Port Huron	638	70	120	29.21	29.92	−.11	30.8	+0.4	70	24	38	4	3	23	29	28	24	78	2.31	+0.2	13	9,049	nw.	35	ne.	30	6	19	6	5.9	13.1	T.
Sault Sainte Marie	614	11	52	29.21	29.93	−.10	21.2	−0.4	46	24	29	−13	6	13	30	18	16	84	1.94	+0.1	17	7,308	nw.	42	nw.	4	7	18	6	5.5	11.2	4.5
Chicago	673	7	131	29.24	29.98	−.05	36.9	+1.6	77	23	44	10	5	30	40	32	26	68	1.50	−1.1	7	8,822	nw.	32	nw.	26	10	9	12	5.7	8.3	T.
Green Bay	617	109	141	29.26	29.95	−.00	29.4	+0.8	67	25	38	−4	5	21	33	26	21	73	2.40	0.0	8	7,628	w.	35	nw.	4	11	11	9	4.8	9.7	0.0
Milwaukee	681	125	221	29.21	29.96	−.07	34.4	+2.3	70	23	42	6	5	26	36	30	24	68	2.22	−0.2	8	10,207	w.	42	nw.	4	8	13	10	5.3	11.7	0.7
Duluth	1,133	5	47	28.72	29.99	−.07	25.0	+1.3	64	24	34	−7	4	16	35	21	16	77	0.83	−0.7	7	8,810	nw.	39	nw.	4	15	10	6	3.9	9.0	0.0
North Dakota							**28.2**	**+6.2**										**75**	**0.49**	**−0.4**										**5.2**		
Moorhead	940	50	58	28.97	30.02	−.06	27.2	+4.5	65	23	37	−4	15	17	30	24	20	78	0.71	−0.3	7	5,357	n.	26	n.	4	12	8	11	5.5	7.4	0.0
Bismarck	1,674	8	57	28.18	30.02	−.04	32.0	+7.8	74	22	43	3	4	21	43	27	22	70	0.32	−0.6	1	5,967	nw.	31	nw.	8	9	14	8	4.7	1.5	0.0
Devils Lake	1,478	11	44	28.40	30.03	−.02	22.7	+4.2	61	21	34	−9	7	12	35	20	17	82	0.67	−0.3	7	6,005	nw.	30	n.	3	15	7	9	4.6	7.9	0.0
Ellendale	1,457	10	56	28.42	30.02	------	31.0	------	72	21	43	4	5	19	41	----	----	----	0.33	------	6	8,488	nw.	38	n.	4	6	13	12	6.1	0.8	0.0
Grand Forks	833	12	67	------	------	------	24.6	------	64	23	35	−9	16	14	34	21	----	----	1.60	------	8	------	nw.	38	nw.	4	17	9	5	----	10.4	0.0
Williston	1,876	41	48	28.00	30.01	−.03	31.1	+8.2	75	22	41	0	4	21	39	27	22	60	0.26	−0.4	3	5,549	w.	26	nw.	1	11	12	8	5.0	0.6	0.0
Upper Mississippi Valley							**39.3**	**+3.2**										**70**	**1.53**	**−0.8**										**5.0**		
Minneapolis	918	102	208	28.96	29.97	------	32.9	+3.3	76	23	42	4	4	24	38	----	----	----	0.93	−0.5	2	7,567	nw.	37	nw.	4	14	5	12	5.2	5.7	0.0
St. Paul	837	236	261	29.06	29.99	−.06	32.6	+3.5	75	23	42	4	4	24	37	----	----	----	0.80	−0.6	2	7,797	nw.	35	nw.	4	13	7	11	5.0	6.1	0.0
La Crosse	714	11	48	29.19	29.98	−.06	34.4	+2.9	78	23	45	6	5	24	40	30	24	72	1.09	−0.5	6	3,712	nw.	21	nw.	4	15	6	10	4.7	5.8	0.0
Madison	974	70	78	28.90	29.99	−.05	33.8	+3.2	75	23	42	6	5	25	40	30	25	75	2.91	+0.8	9	6,925	nw.	32	ne.	26	14	6	11	4.9	10.6	T.
Wausau	1,247	4	------	28.59	29.96	------	29.2	------	70	25	40	−5	5	19	38	----	----	----	1.06	------	7	------	n.	----	----	----	15	7	9	4.8	8.8	0.0
Charles City	1,015	10	49	28.89	30.00	−.05	35.0	+4.3	78	23	45	7	5	25	40	30	26	72	1.34	−0.6	6	4,849	nw.	31	nw.	24	15	7	9	4.4	7.2	0.0
Davenport	606	71	79	29.32	29.99	−.04	40.0	+3.9	81	23	49	12	5	31	37	34	29	70	2.61	+0.3	7	5,392	nw.	26	e.	29	13	8	10	5.2	5.2	T.
Des Moines	861	84	97	29.06	29.99	−.05	40.8	+4.9	84	23	51	14	5	31	42	35	29	67	1.71	−0.1	5	5,020	n.	26	sw.	23	11	11	9	5.2	1.4	0.0
Dubuque	700	81	96	29.21	29.98	−.06	37.4	+3.4	80	23	46	10	5	29	40	32	26	66	2.14	+0.1	7	5,160	nw.	28	nw.	4	12	8	11	5.3	3.7	T.
Keokuk	614	64	78	29.32	30.00	−.03	42.6	+3.7	81	23	52	15	5	33	35	36	29	64	1.39	−1.0	7	5,711	nw.	25	w.	12	11	8	12	5.4	3.1	0.0
Cairo	358	87	93	29.62	30.02	−.02	47.6	+0.4	79	22	57	24	5	38	33	41	35	69	1.23	−2.5	7	7,028	s.	33	nw.	26	7	8	16	6.4	0.1	0.0
Peoria	609	11	45	29.33	30.01	−.02	40.4	+3.4	82	23	50	14	5	30	35	34	30	73	0.96	−1.8	6	5,732	nw.	22	nw.	26	16	7	8	3.8	2.5	0.0
Springfield, Ill	636	10	91	29.30	29.99	−.04	42.2	+2.0	81	23	51	17	5	33	34	37	32	71	1.14	−2.0	8	6,500	s.	26	nw.	26	10	9	12	5.3	0.7	0.0
Hannibal	534	74	109	29.42	30.00	−.02	44.0	+3.0	82	23	54	17	5	34	37	----	----	----	0.93	−1.8	9	6,761	sw.	25	ne.	29	10	13	8	4.9	0.8	0.0
St. Louis	568	265	303	29.38	30.00	−.03	46.0	+2.2	81	23	56	20	5	36	30	40	36	72	2.27	−1.1	6	8,729	sw.	36	nw.	26	13	11	7	4.7	0.2	0.0
Missouri Valley							**42.9**	**+5.3**										**64**	**1.04**	**−0.9**										**4.8**		
Columbia, Mo	784	11	84	29.14	29.99	−.04	46.0	+3.4	83	22	57	18	5	35	41	----	----	----	0.69	−2.3	6	6,220	s.	32	nw.	26	11	12	8	4.7	0.3	0.0
Kansas City	963	161	181	28.94	29.99	−.03	47.4	+4.7	84	25	58	17	5	36	36	39	32	60	0.36	−2.2	2	7,744	s.	37	nw.	26	12	13	6	4.7	1.5	0.0
St. Joseph	967	11	49	28.93	29.98	------	46.3	------	86	22	58	17	5	35	39	38	29	59	0.77	------	6	6,219	nw.	30	nw.	26	13	13	5	4.6	1.8	0.0
Springfield, Mo	1,324	98	104	28.58	30.00	−.02	46.8	+1.6	78	28	57	19	5	37	36	40	33	65	2.36	−1.7	10	7,275	s.	34	se.	28	21	6	4	3.0	0.8	0.0
Iola	984	11	50	28.93	30.00	−.01	48.4	+3.9	85	25	61	18	5	36	42	----	----	----	1.78	−1.1	5	4,905	s.	26	n.	26	12	13	6	4.6	5.0	0.0
Topeka	987	92	107	------	------	------	47.8	+5.2	85	22	60	18	5	36	30	----	----	----	0.53	−1.8	5	7,048	sw.	33	n.	26	14	12	5	4.1	0.5	0.0
Lincoln	1,189	11	81	28.70	29.99	−.03	43.4	+5.9	87	22	56	15	5	31	48	35	26	57	0.46	−0.9	4	6,943	n.	34	nw.	26	13	5	13	5.2	0.8	0.0
Omaha	1,105	115	122	28.80	30.00	−.04	43.2	+6.2	84	23	53	18	5	33	45	36	28	61	0.47	−0.9	4	5,824	nw.	31	n.	4	12	9	10	5.0	0.3	0.0
Valentine	2,598	47	54	27.25	30.02	−.01	38.2	+5.9	80	22	52	6	30	25	44	31	24	63	2.00	+0.8	7	6,198	w.	28	nw.	17	11	12	8	4.9	14.2	0.0
Sioux City	1,135	94	164	28.78	30.02	−.03	40.0	+7.3	85	23	50	18	5	30	42	34	29	70	1.17	−0.1	5	7,421	nw.	31	nw.	12	11	7	13	5.6	2.0	0.0
Huron	1,306	59	74	28.59	30.02	−.04	36.2	+7.3	78	21	48	10	4	24	46	30	23	67	0.28	−0.6	4	5,792	nw.	27	n.	4	7	15	9	5.6	2.9	0.0
Pierre	1,572	70	75	------	30.03	−.02	38.0	+6.5	83	22	51	12	30	25	49	----	----	76	0.97	−0.4	6	5,862	nw.	29	ne.	28	10	6	15	----	7.5	T.
Yankton	1,233	49	57	28.66	30.01	−.04	39.2	+6.0	86	23	50	18	4	29	47	----	----	----	1.43	+0.2	6	4,923	nw.	22	nw.	26	8	14	9	5.5	4.2	0.0

TABLE 1.—*Climatological data for Weather Bureau Stations, March, 1928*—Continued

District and station	Elevation of instruments: Barometer above sea level	Thermometer above ground	Anemometer above ground	Pressure: Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Departure from normal	Days with .01, or more	Wind (3-cup anemometer used): Total movement	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0–10	In.	In.
Northern Slope							35.9	+4.2										64	0.93	−0.2										5.6		
Billings	3,140	5					40.8		79	22	55	14	1	26	49				0.16		4		nw.				11	8	12		1.0	0.0
Havre	2,505	11	44	27.29	29.97	0.03	36.2	+9.1	75	22	48	7	29	24	47	30	24	67	0.34	−0.2	6	5,474	e.	36	sw.	24	7	10	14	6.2	2.7	0.0
Helena	4,110	87	112	25.73	29.99	0.02	37.6	+5.2	73	21	47	4	1	28	36	31	22	57	0.52	−0.2	7	4,987	sw.	33	sw.	24	8	6	17	6.1	5.3	0.0
Kalispell	2,973	48	56	26.87	29.97	−.02	36.8	+3.9	66	20	46	5	1	28	35	32	27	70	0.74	−0.3	10	3,563	nw.	27	sw.	25	9	10	12	5.9	1.2	0.0
Rapid City	3,259	50	58	26.56	30.04	+.03	37.4	+4.8	76	21	49	10	5	26	37	31	22	56	0.89	−0.2	9	5,313	n.	29	n.	17	9	10	12	5.6	8.1	0.0
Cheyenne	6,088	84	101	23.93	30.01	+.05	34.1	+1.0	68	22	45	−1	1	23	39	28	22	63	1.52	+0.5	9	8,919	w.	42	w.	25	7	8	16	6.3	11.0	T.
Lander	5,372	60	68	24.58	30.02	+.05	34.4	+2.0	67	22	48	−4	1	21	37	28	22	63	0.45	−1.2	3	3,519	sw.	44	sw.	27	18	15	3	4.6	4.7	0.0
Sheridan	3,790	10	47	26.04	30.01		36.6		78	22	50	1	2	23	48	31	25	70	0.76		7	3,050	nw.	31	nw.	11	11	12	8	4.9	7.4	0.0
Yellowstone Park	6,241	11	48	23.82	30.06	+.04	30.0	+3.5	57	21	41	−5	1	19	39	25	19	68	1.60	−0.6	13	5,441	sw.	29	sw.	31	9	7	15	5.9	15.6	4.0
North Platte	2,821	11	51	27.03	30.00	.00	40.8	+4.2	83	23	54	7	16	27	45	33	25	61	1.40	+0.5	5	5,147	n.	24	n.	25	12	11	8	4.7	3.0	0.0
Middle Slope							46.4	+3.1										58	1.52	+0.1										5.0		
Denver	5,292	106	113	24.67	29.99	+.04	42.0	+2.7	72	27	53	10	16	31	41	32	21	52	1.40	+0.4	8	4,894	s.	41	nw.	25	8	15	8	5.3	15.8	0.0
Pueblo	4,685	80	86	25.23	29.96	+.04	43.4	+1.8	76	27	57	5	16	30	47	34	24	54	1.41	+0.6	6	4,413	nw.	31	w.	25	10	13	8	5.1	13.2	0.0
Concordia	1,392	50	58	28.52	30.01	.00	46.4	+5.4	84	22	58	19	5	34	33	38	29	58	0.47	−0.8	3	5,841	nw.	28	nw.	26	14	6	11	5.0	0.4	0.0
Dodge City	2,509	11	51	27.38	30.02	+.05	45.3	+2.5	81	23	58	14	17	32	40	37	29	62	1.84	+1.0	3	6,926	nw.	33	ne.	15	21	5	5	3.2	10.8	0.0
Wichita	1,358	139	158	28.53	29.98	−.01	48.0	+2.9	81	25	59	21	5	37	35	41	34	65	2.24	0.0	8	8,484	s.	32	ne.	15	13	14	4	4.6	8.2	0.0
Broken Arrow	765	11	56	29.07	30.00		51.3		84	25	62	20	5	41	35				2.23		7	8,979	s.	42	n.	26	9	9	13	5.9	9.3	0.0
Oklahoma City	1,214	10	47	28.69	29.98	.00	53.1	+3.1	88	28	64	25	17	42	38	43	35	59	1.75	−0.6	4	6,820	n.	35	n.	26	9	12	10	5.6	0.2	0.0
Southern Slope							57.4	+2.8										47	0.41	−0.5										3.9		
Abilene	1,738	10	52	28.15	29.96	.00	59.0	+2.5	96	28	72	24	17	46	42	46	33	49	0.43	−0.9	3	7,201	s.	20	sw.	31	9	13	9	5.2	T.	0.0
Amarillo	3,676	10	49	26.22	29.96	+.01	50.0	+3.1	83	27	63	21	16	37	50	39	29	53	0.86	+0.2	7	6,211	sw.	26	e.	14	19	5	7	3.9	0.2	0.0
Del Rio	944	64	71	28.93	29.91	−.04	66.4	+2.9	103	28	79	33	17	54	46	53	40	49	0.35	−0.8	2	6,412	se.	33	nw.	16	20	5	6	3.3	0.0	0.0
Roswell	3,566	75	85	26.32	29.92	+.02	54.0	+2.7	88	27	70	22	17	38	47	41	24	37	T.	−0.6	0	6,116	s.	34	n.	15	16	13	2	3.2	0.0	0.0
Southern Plateau							54.2	+3.4										43	0.40	−0.1										3.0		
El Paso	3,778	110	133	26.15	29.91	+.03	58.9	+3.1	88	27	72	28	16	46	36	42	23	29	0.05	−0.3	2	7,817	w.	47	w.	28	23	7	1	1.9	0.4	0.0
Santa Fe	7,013	38	53	23.19	29.92	+.03	41.8	+2.1	70	27	53	7	16	30	31	32	21	49	1.31	+0.5	5	4,420	n.	33	w.	27	10	13	8	5.2	9.6	0.0
Flagstaff	6,907	10	50	23.32	29.92	+.01	39.8	+3.9	66	26	53	13	29	27	42	32		60	0.40		5	6,170	nw.	37	sw.	27	11	14	6		T.	0.0
Phoenix	1,108	10	82	28.78	29.93	+.02	64.1	+3.4	89	21	70	40	16	50	43	49	33	37	0.13	−0.4	1	2,860	e.	22	n.	15	20	6	5	3.1	0.0	0.0
Yuma	141	9	54	29.81	29.96	+.02	66.6	+2.5	95	21	82	45	30	51	44	52	36	30	0.11	−0.2	1	3,588	w.	27	n.	15	24	6	1	1.7	0.0	0.0
Independence	3,957	5	25	25.94	29.97	+.03	54.0	+5.5	79	21	68	20	29	39	42	53			0.34		4		nw.				19	10	2	3.0	0.0	0.0
Middle Plateau							44.4	+3.5										58	1.85	+0.7										5.8		
Reno	4,532	74	81	25.46	30.01	+.03	45.2	+4.2	73	20	56	25	15	34	42	38	31	61	2.34	+1.5	11	4,616	w.	35	sw.	26	9	13	9	5.8	1.6	0.0
Tonopah	6,090	12	20				43.6		68	26	52	22	28	35	28	35	22	49	0.58		5		se.									
Winnemucca	4,344	18	56	25.62	30.03	+.02	43.3	+3.3	74	21	56	17	15	30	47	37	29	62	1.90	+0.9	10	5,353	sw.	30	sw.	31	9	17	5	5.6	T.	0.0
Modena	5,473	10	43	24.60	29.96	.00	42.4	+4.2	71	21	55	20	30	30	43	36	28	64	1.01	−0.3	8	6,798	w.	50	sw.	25	11	11	9	4.7	0.1	0.0
Salt Lake City	4,360	163	203	25.61	30.01	+.03	45.2	+3.5	73	21	54	29	15	36	32	38	29	56	2.78	+0.8	14	4,607	nw.	36	nw.	25	10	8	13	5.2	2.3	0.0
Grand Junction	4,602	60	68	25.35	29.94	.00	46.0	+2.4	73	22	57	26	30	35	39	37	27	54	1.24	+0.5	11	3,660	se.	34	nw.	27	8	10	13	5.7	0.2	0.0
Northern Plateau							44.2	+2.8										54	1.81	+0.4										6.5		
Baker	3,471	46	53	26.44	30.05	+.02	39.8	+2.2	70	19	49	14	1	30	36	35	28	66	0.86	−0.6	14	4,410	se.	21	s.	31	6	5	20	7.1	3.9	0.0
Boise	2,739	78	86	27.19	30.07	+.04	45.4	+2.7	77	21	55	25	15	36	37	39	32	63	2.46	+1.1	13	3,523	se.	21	w.	9	9	7	15	6.2	T.	0.0
Lewiston	757	40	48	29.21	30.02	−.01	47.9	+2.5	75	20	58	24	1	38	38				1.47	+0.2	16	2,668	e.	21	nw.	24	7	3	21	6.9	0.0	0.0
Pocatello	4,477	60	68	25.45	30.02	+.01	40.8	+3.4	70	20	50	12	1	31	33	34	28	64	1.59	−0.2	8	5,972	se.	34	sw.	27	7	10	14	5.8	T.	0.0
Spokane	1,929	101	110	27.94	30.01	.00	42.7	+3.0	68	19	52	17	1	34	32	38	32	68	1.88	+0.7	19	4,637	s.	20	sw.	24	6	9	16	6.7	T.	0.0
Walla Walla	991	57	65	28.93	30.01	−.01	48.8	+2.7	71	20	57	28	1	40	28	43	37	64	2.59	+1.0	17	3,554	s.	21	sw.	11	8	7	16	6.3	0.0	0.0
North Pacific Coast Region							48.8	+3.6										76	7.00	+2.9										7.5		
North Head	211	11	56	29.69	29.92	−.09	48.6	+3.4	76	18	53	37	14	44	30	46	42	83	7.23	+2.6	24	13,070	s.	62	s.	21	3	2	26	8.5	0.0	0.0
Port Angeles	29	8	53		29.95		45.1		63	19	52	30	14	38	23				2.85	+0.7	18	3,882	sw.	30	ne.	26	5	11	15		1.0	0.0
Seattle	125	215	250	29.82	29.95	−.04	48.2	+3.3	76	19	54	33	14	42	29	44	39	74	5.87	+3.2	22	7,257	s.	34	se.	26	5	4	22	7.5	0.0	0.0
Tacoma	194	172	201	29.76	29.97	−.03	47.9	+3.7	77	19	55	31	14	41	33				7.67	+4.1	24	6,371	s.	36	s.	27	5	8	18	7.0	0.0	0.0
Tatoosh Island	86	9	53	29.80	29.90	−.06	46.2	+3.3	58	19	50	35	25	43	15	44	42	87	12.42	+3.8	24	13,372	e.	74	e.	26	4	7	20	7.5	0.0	0.0
Yakima	1,071	5					45.9		74	19	60	21	4	32	41	39		67	0.70		5		sw.				8	8	15	5.8	T.	0.0
Medford	1,425	4	80	28.49	30.00		49.4		81	18	60	31	14	38	43	44	40	74	3.24		15		w.	24	se.	21	2	5	24	8.5	T.	0.0
Portland, Oreg.	153	68	106	29.84	30.00	−.02	50.8	+3.9	76	19	58	32	14	44	27	46	41	72	7.21	+3.3	22	4,862	sw.	23	e.	26	6	5	20	7.1	0.0	0.0
Roseburg	510	75	99	29.47	30.02	−.02	50.9	+3.8	76	18	59	33	12	42	28	47	43	78	5.71	+2.4	19	2,739	s.	26	sw.	26	0	12	19	8.0	0.0	0.0
Middle Pacific Coast Region							56.3	+3.4										79	4.19	+0.8										6.1		
Eureka	62	73	89	30.01	30.08	+.02	52.1	+3.8	66	21	58	40	12	46	19	49	48	87	7.01	+1.8	18	4,218	se.	28	sw.	26	4	6	21	7.6	0.0	0.0
Red Bluff	332	50	56	29.68	30.04	.00	56.7	+3.1	86	18	66	35	28	47	36	51	46	72	3.78	+0.5	13	3,671	se.	26	se.	26	11	10	10	5.3	0.0	0.0
Sacramento	69	106	117	29.98	30.05	+.02	56.5	+2.2	79	18	65	43	29	48	29	52	49	79	3.39	+0.8	11	5,005	se.	25	se.	26	11	6	14	5.4	0.0	0.0
San Francisco	155	208	243	29.89	30.06	.00	58.2	+4.0	77	17	64	47	28	52	26	53	50	79	4.65	+1.5	15	4,862	w.	30	s.	26	9	8	14	5.9	0.0	0.0
San Jose	141	12	110	29.92	30.07		57.8	+4.1	83	18	67	30	28	48	35				2.12	−0.5	12	4,055	se.	28	nw.	27	8	8	15	6.2	0.0	0.0
South Pacific Coast Region							59.8	+3.4										73	1.33	−0.7										4.9		
Fresno	327	89	98	29.71	30.07	+.06	59.4	+4.4	86	18	70	39	29	48	34	52	46	68	1.32	−0.3	8	4,094	nw.	21	nw.	28	10	12	9	5.0	0.0	0.0
Los Angeles	338	159	191	29.60	30.06	+.04	60.6	+3.1	83	18	69	48	28	53	30	53	47	70	1.99	−0.8	6	3,567	sw.	24	nw.	28	14	5	12	5.1	0.0	0.0
San Diego	87	62	70	29.96	30.05	+.03	59.4	+2.7	74	16	66	46	29	53	23	54	51	80	0.69	−1.0	7	4,192	nw.	21	w.	28	14	9	8	4.6	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.94	30.03		75.2	−0.2	87	19	81	67	12	70	18				1.67	−1.5	10	8,809	e.	28	e.	15	13	15	3	4.6	0.0	0.0
Panama Canal																																
Balboa Heights	118	7	97	[1] 29.77	[1] 29.85	+.01	81.8	+0.6	93	23	90	71	1	73	21				4.07	+3.3	3		nw.		nw.		11	18	2	4.9	0.0	0.0
Colon	38	7	97	[1] 29.88	[1] 29.89	+.01	82.0	+1.4	90	18	87	73	12	77	15				2.42	+0.9	14		n.		n.		5	19	7	5.8	0.0	0.0
Alaska																																
Juneau	80	11	54	[2] 29.61	[2] 29.70		32.2		47	27	37	11	7	27	18	30	25	75	6.74		18	5,800	se.	25	s.	14	5	4	22	7.8	22.4	0.0
Hawaiian Islands																																
Honolulu	38	86	100	[2] 30.00	[2] 30.04		73.1		81	19	78	60	25	68	14	66	63	72	1.02	−2.2	9	5,721	e.	28	sw.	24	10	13	8	5.2	0.0	0.0
San Juan, P. R.[3]	82	9	54	29.79	29.87		80.3	+0.5	94	20	86	71	30	75	18				12.15	+6.0	21	6,181	e.	39	e.	31	7	18	6	5.5	0.0	0.0

[1] Observations taken bihourly. [2] Pressure not corrected to mean of 24 hours. [3] Late report, October, 1927.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, March, 1928*

Stations	Altitude above mean sea leve Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*Inches*	*Inches*	*Inches*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*
Cape Race, N. F.	99				26.1		31.4	20.8	43	4	2.72		0.0
Sydney, C. B. I.	48	29.74	29.79	-0.09	27.4	+1.2	34.7	20.1	49	0	3.40	-1.53	17.0
Halifax, N. S.	88	29.70	29.81	-.13	29.9	+0.9	37.8	22.0	50	3	2.68	-2.78	9.6
Yarmouth, N. S.	65	29.67	29.74	-.21	31.1	+0.3	36.8	25.4	56	10	2.98	-2.02	8.7
Charlottetown, P. E. I.	38	29.66	29.70	-.20	26.9	+1.5	33.2	20.7	52	4	3.19	-0.02	19.3
Chatham, N. B.	28	29.63	29.66	-.24	24.2	+1.2	32.9	15.5	52	-13	2.86	-0.61	24.8
Father Point, Que.	20												
Quebec, Que.	296	29.46	29.79	-.17	22.2	+1.0	28.6	15.7	39	-5	2.95	-0.31	21.4
Doucet, Que.	1,236												
Montreal, Que.	187	29.59	29.81	-.19	25.7	+1.9	32.1	19.3	53	2	3.42	-0.37	23.0
Ottawa, Ont.	236	29.58	29.86	-.15	25.0	+3.5	33.0	17.1	52	-5	2.69	-0.03	19.5
Kingston, Ont.	285												
Toronto, Ont.	379	29.47	29.90	-.12	30.6	+3.3	37.6	23.6	71	9	2.22	-0.42	11.7
Cochrane, Ont.	930												
White River, Ont.	1,244												
London, Ont.	808				29.8		38.2	21.4	71	2	3.16		21.0
Southampton, Ont.	656	29.16	29.90	-.13	24.9	+0.2	31.7	18.1	54	-8	2.77	+0.12	23.7
Parry Sound, Ont.	688												
Port Arthur, Ont.	644	29.22	29.95	-.10	23.0	+6.2	32.8	13.2	58	-10	0.60	-0.37	6.0
Winnipeg, Man.	760												
Minnedosa, Man.	1,690	28.16	30.06	.00	18.9	+6.4	29.4	8.4	58	-19	1.14	+0.49	11.4
Le Pas, Man.	860				15.5		27.7	3.3	59	-21	0.35		3.5
Qu'Appelle, Sask.*	2,115	27.66	29.97	-.07	21.1	+6.2	30.8	11.4	66	-12	1.28	+0.51	12.8
Moose Jaw, Sask.	1,759				28.2		38.0	18.4	73	-7	0.70		6.0
Swift Current, Sask.	2,392	27.35	29.93	-.09	31.2	+0.2	42.1	20.3	71	-2	0.63	-0.18	5.7
Medicine Hat, Alb.	2,144	27.59	29.89	-.11	35.0	+7.5	46.5	23.4	68	6	0.08	-0.68	0.8
Calgary, Alb.	3,428												
Banff, Alb.	4,521	25.24	29.90	-.04	30.1	+9.9	41.2	18.9	63	3	1.47	+0.06	13.2
Prince Albert, Sask.	1,450	28.43	30.06	-.02	22.2	+10.2	33.5	10.9	60	-22	0.38	-0.39	2.3
Battleford, Sask.	1,592	28.21	30.01	-.05	24.3	+11.2	35.1	13.5	62	-12	0.63	+0.17	6.3
Edmonton, Alb.	2,150	27.56	29.90	-.06	26.3	+2.1	36.2	16.4	65	-10	1.20	+0.48	12.0
Kamloops, B. C.	1,262												0.0
Victoria, B. C.	230	29.67	29.92	-.05	46.7	+4.8	52.7	40.8	67	34	2.09	-1.03	0.0
Barkerville, B. C.	4,180												
Estevan Point, B. C.	20												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	29.94	30.11	+.03	63.5	+1.3	70.2	56.9	75	49	5.82	+0.69	0.0

* Record for 27 days only.

LATE REPORTS, FEBRUARY, 1928

Cape Race, N. F.	99				23.0		29.5	16.5	37	0	3.49		9.5
Kamloops, B. C.	1,262	28.96	30.30	+.34	30.8	+2.5	37.5	24.2	45	3	0.07	-0.72	0.7
Barkerville, B. C.	4,180	25.72	30.14	+.23	22.9	+4.0	31.2	14.6	41	-11	3.70	+0.64	37.0
Estevan Point, B. C.	20				41.8		47.3	36.3	53	28	7.91		0.0

Chart I. Departure (°F.) of the Mean Temperature from the Normal, March, 1928

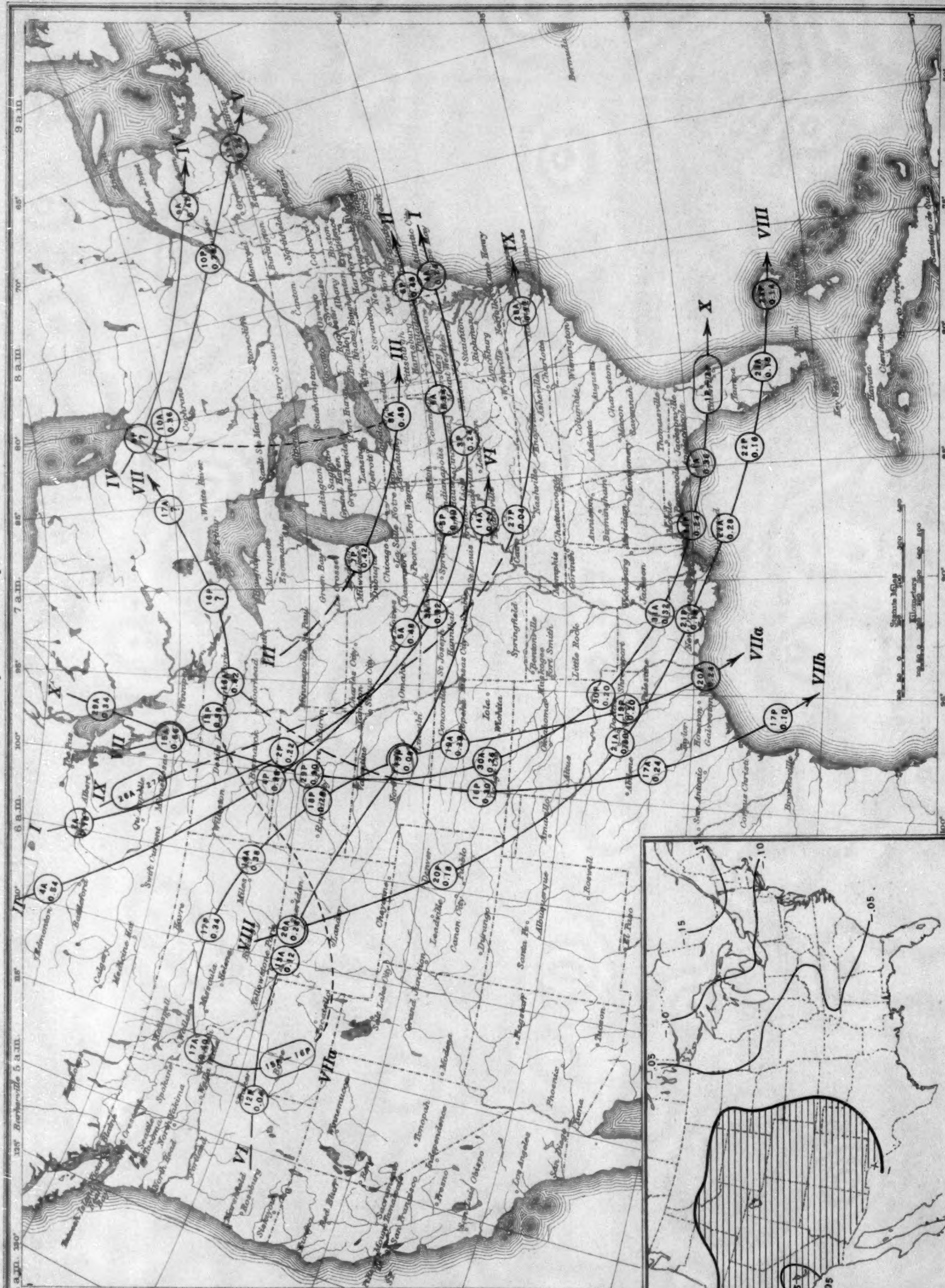

Chart II. Tracks of Centers of Anticyclones, March, 1928. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by Wilfred P. Day)

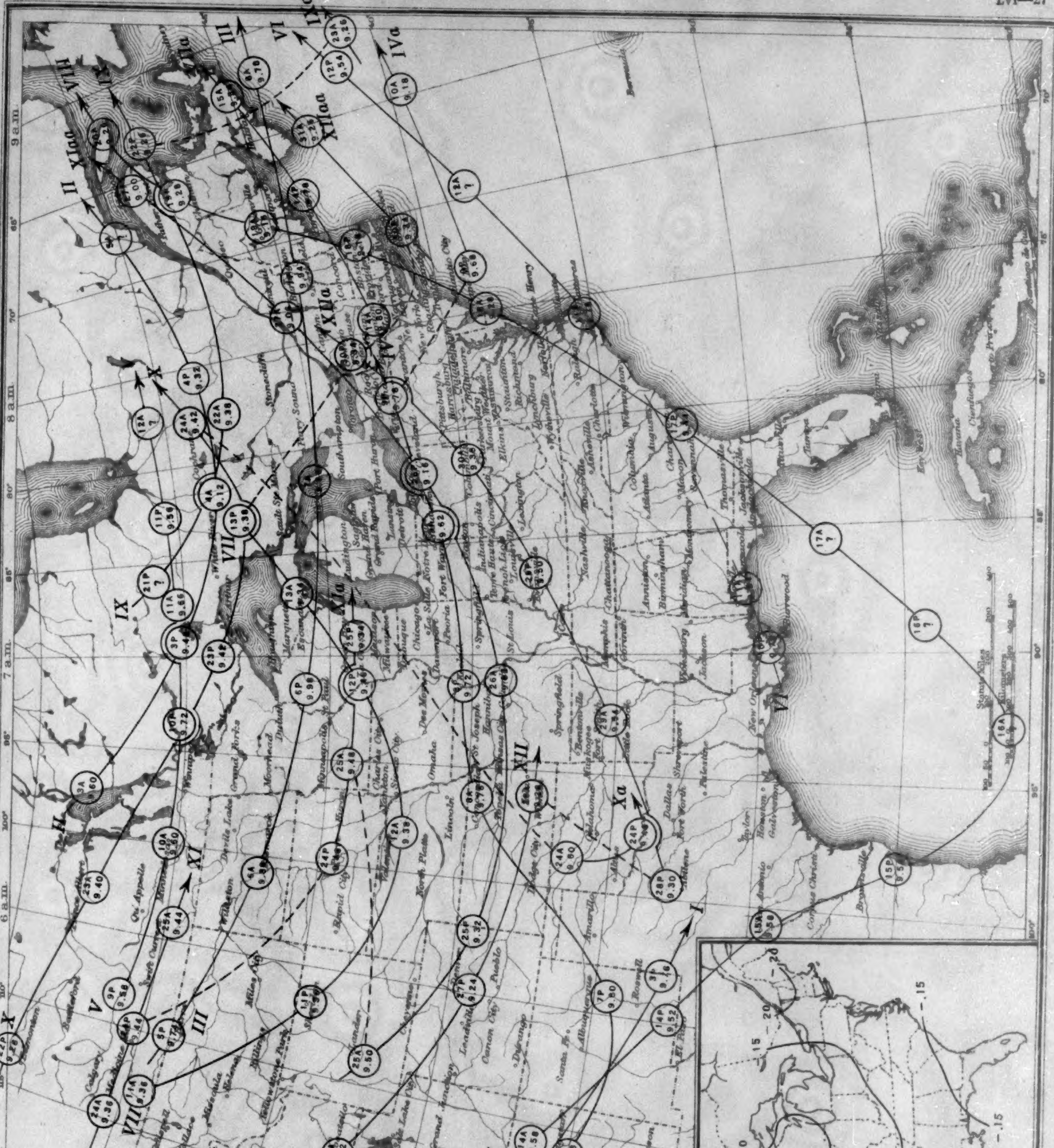

Chart III. Tracks of Centers of Cyclones, March, 1928. (Inset) Change in Mean Pressure from Preceding Month
(Plotted by Wilfred P. Day)

Chart IV. Percentage of Clear Sky between Sunrise and Sunset, March, 1928

Chart V. Total Precipitation, Inches, March, 1928. (Inset) Departure of Precipitation from Normal

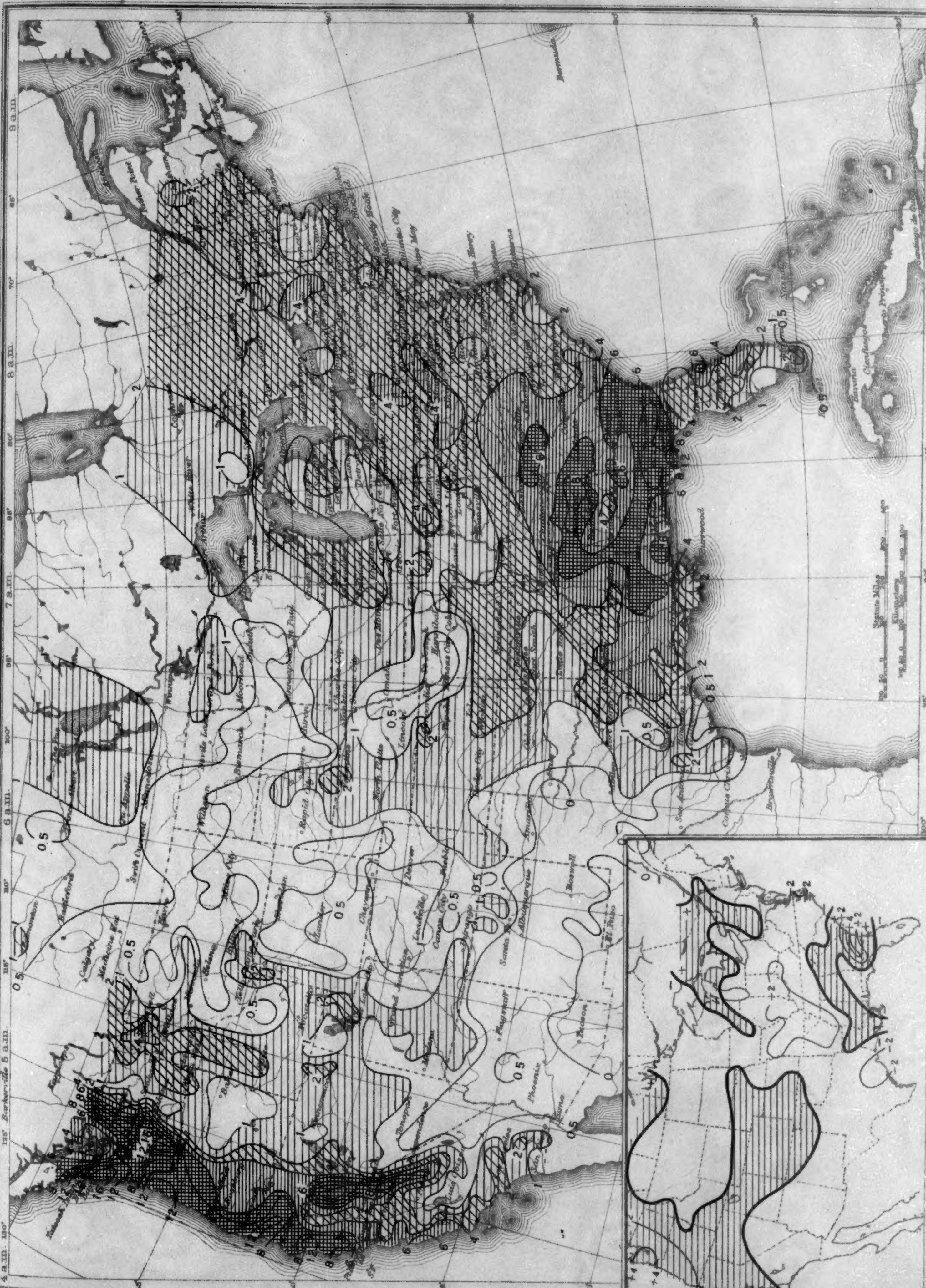

Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, March, 1928

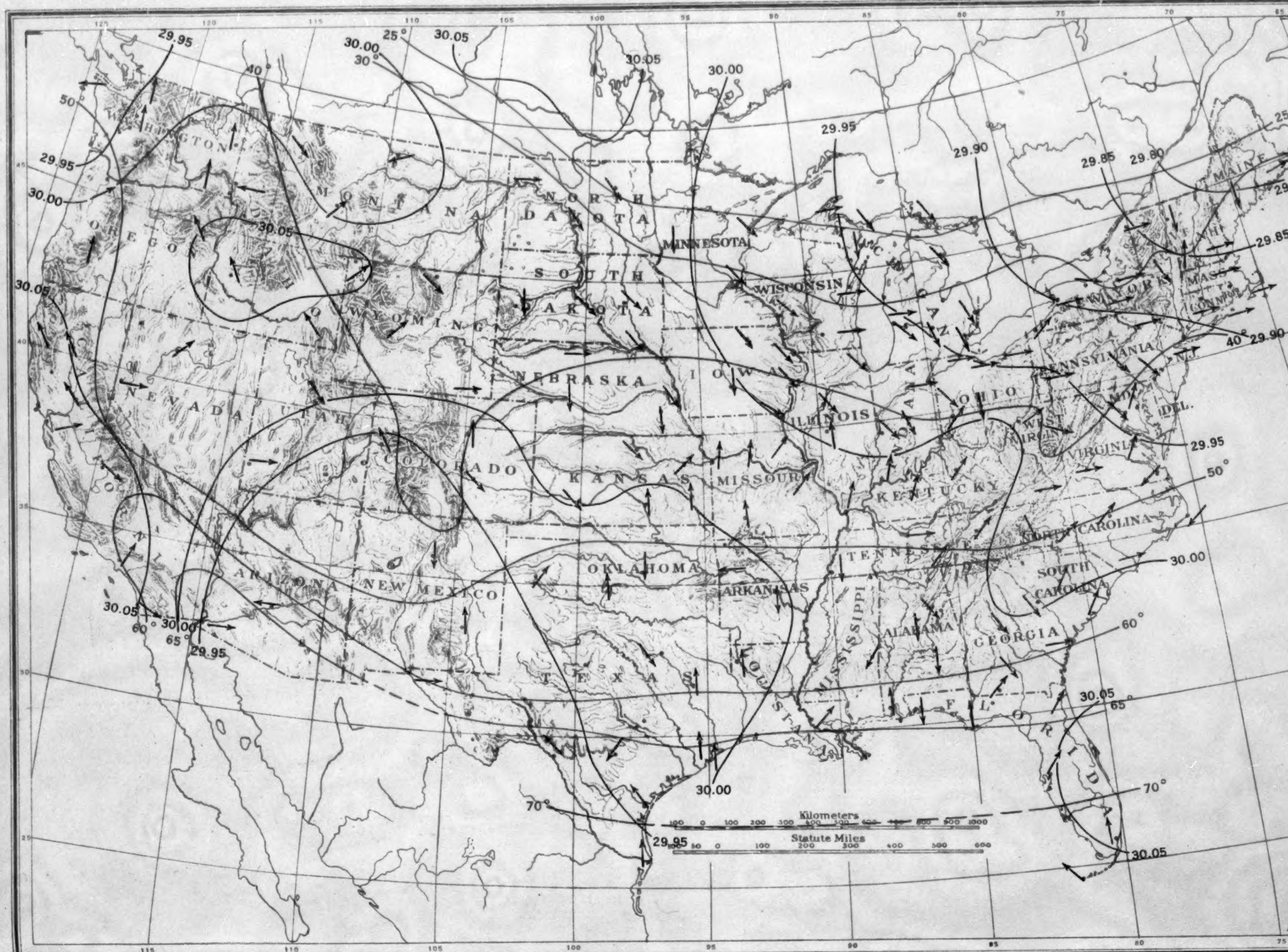

Chart VII. Total Snowfall, Inches, March, 1928. (Inset) Depth of Snow on Ground at end of Month

Chart VII. Total Snowfall, Inches, March, 1928. (Inset) Depth of Snow on Ground at end of Month

Chart VIII. Weather Map of North Atlantic Ocean, March 10, 1928
(Plotted by F. A. Young)

Chart VIII. Weather Map of North Atlantic Ocean, March 10, 1928
(Plotted by F. A. Young)

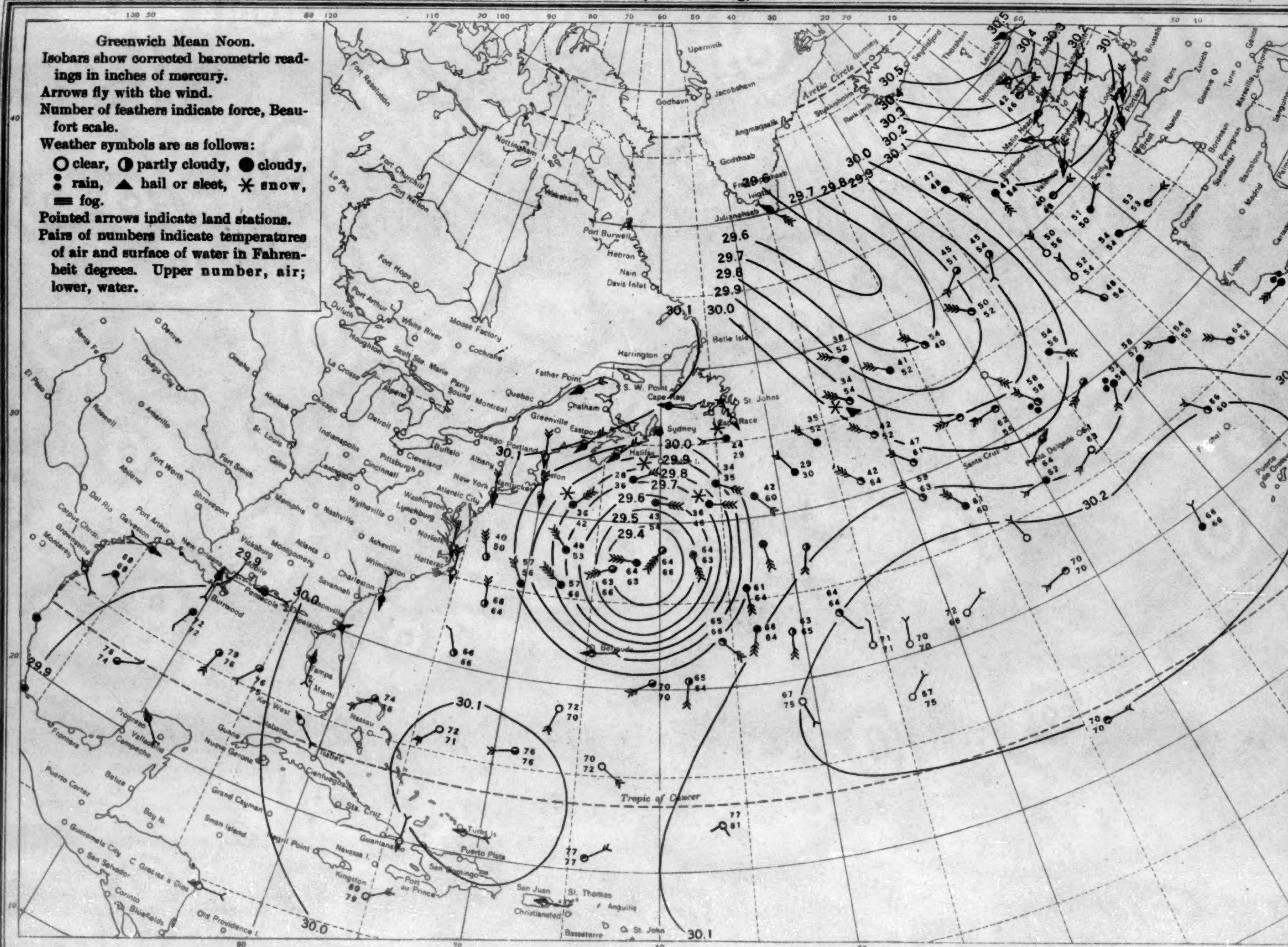

Chart IX. Weather Map of North Atlantic Ocean, March 11, 1928
(Plotted by F. A. Young)

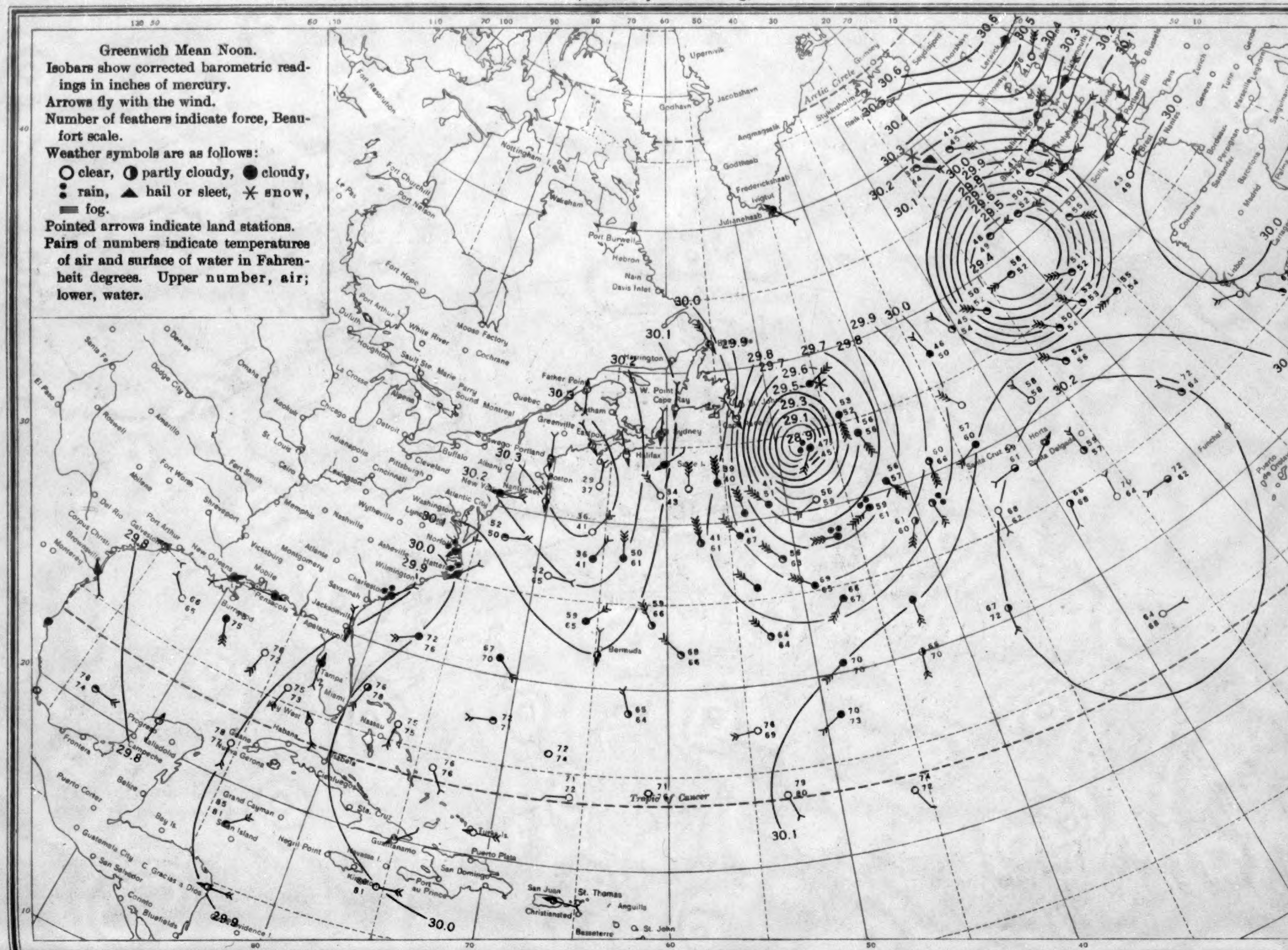

Chart X. Weather Map of North Atlantic Ocean, March 12, 1928
(Plotted by F. A. Young)

Chart X. Weather Map of North Atlantic Ocean, March 12, 1928

(Plotted by F. A. Young)

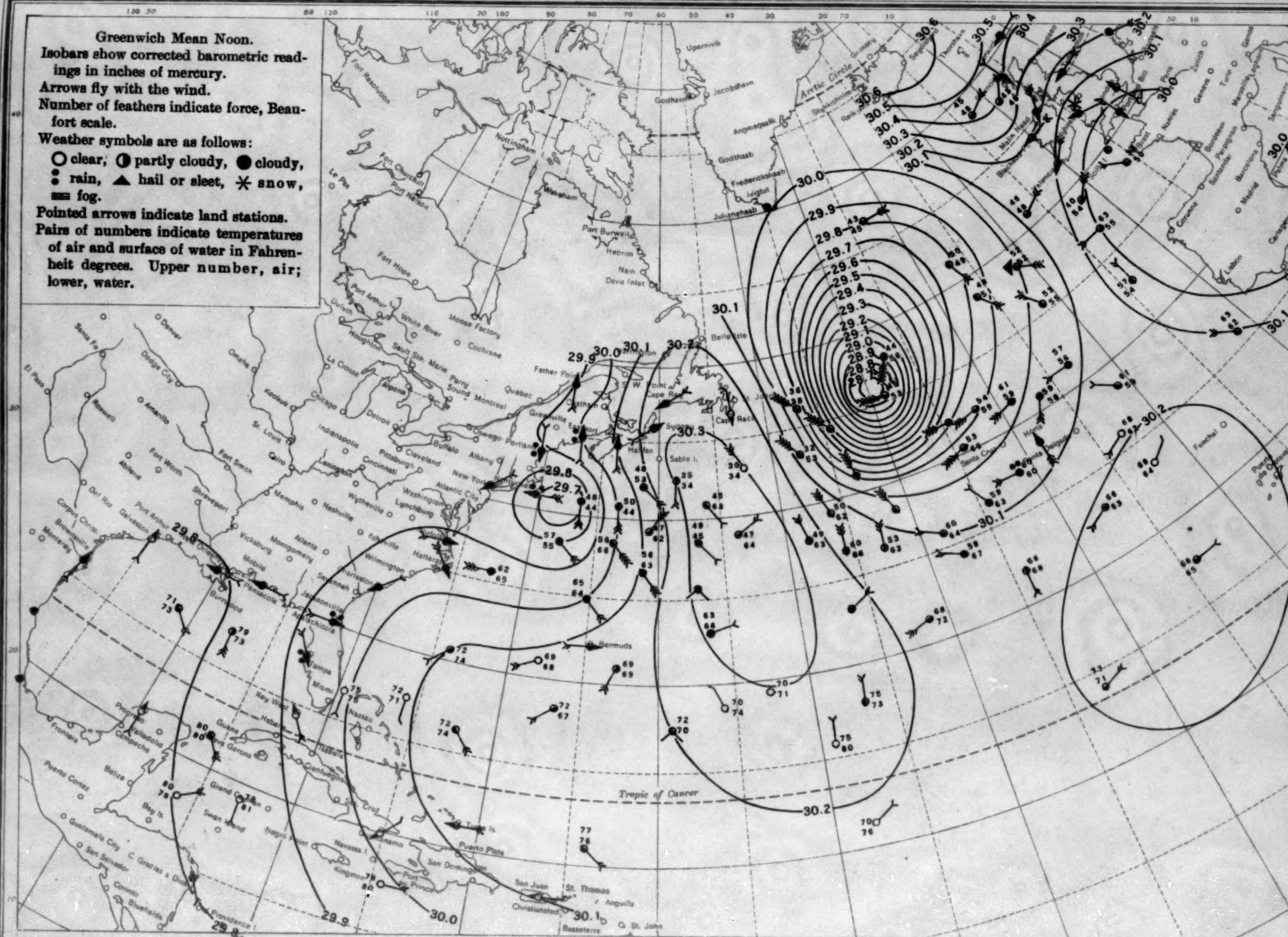

Chart XI. Weather Map of North Atlantic Ocean, March 13, 1928

(Plotted by F. A. Young)